# THE JANUARY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL



THE SCIENCE PRESS
LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.
Yearly Subscription $5.00 Single Copies 50 cents

# NEW BOOKS OF SCIENTIFIC INTEREST

**A Newton among Poets.** CARL GRABO. xii + 208 pp. $3.00. University of North Carolina Press.

This is a study of Shelley's scientific background and his use of science in "Prometheus Unbound." Chapters are devoted to sketching those aspects of the thought of Darwin, Herschel, Newton and Davy which seem to bear most closely upon it.

---

**The Growth of Ability.** RAYMOND O. FILTER and OMAR C. HELD. vii + 174 pp. $2.28. Warwick & York.

The aim of this book is to present the major problems of the psychology of learning without abstracting them from their natural settings. This is the twenty-eighth volume in a series of monographs on educational psychology.

---

**The Parade of the Living.** JOHN HODGDON BRADLEY, JR. 309 pp. $3.00. Coward-McCann.

The author presents a philosophical interpretation of the geological history of life on earth. The parade of organisms through time is examined for its significance to modern man, the better to understand his position.

---

**The Green Leaf.** D. T. MACDOUGAL. 142 pp. Illustrated. $2.00. D. Appleton & Company.

An account of the major activities of plants in sunlight, intended to give the general reader a fundamental comprehension of the plant's vital processes in the light of the most modern scientific advances. Written by a pioneer in plant study.

---

**Artificial Sunlight.** M. LUCKIESH. 254 pp. $3.75. D. Van Nostrand Company.

An account of the new development in the science of illumination combining radiation for health with light for vision. In this treatise the effects of radiant energy have been coordinated with the physics of the subject.

---

**Plant Physiological Chemistry.** RODNEY BEECHER HARVEY. xix + 413 pp. Illustrated. $6.00. Century Company.

It is the purpose of this text to present the physiological chemical mechanism of the vital processes of plants. The main part of the discussion is devoted to the synthesis, translocation, storage, digestion and utilization of substances within the plant.

---

**Simplified Aerodynamics.** ALEXANDER KLEMIN. 323 pp. Illustrated. $3.50. Goodheart-Willcox Company.

The author has attempted to set forth clearly and simply the fundamental principles of aerodynamics, with a minimum of mathematical symbols. It is intended for those engaged in the aviation industry and those learning to fly.

---

**The Mixed Courts of Egypt.** JASPER YEATES BRINTON. xxvii + 416 pp. Illustrated. $5.00. Yale University Press.

This volume is concerned with the mixed courts of Egypt which have jurisdiction over all litigation which involves a foreign party or a foreign interest. The origin, history and the legislative administrative and judicial functions of the entire system are discussed.

---

**The Psychology of Achievement.** WALTER B. PITKIN. xi + 502 pp. $3.50. Simon & Schuster.

This book discusses the factors of personality which make for achievement, in the hope that its readers may gauge their own aptitudes and direct their efforts with intelligence. The work is based largely on a study of successful men.

---

**Our Plant Friends and Foes.** WILLIAM A. DU PUY. xiv + 277 pp. Illustrated. $1.00. John C. Winston Company.

This book has been written for the reader of average intelligence, to give some insight into the simple phenomena of the more common plants. In preparing the volume the author has had the cooperation of the U. S. Department of Agriculture.

---

**Clio Medica.** Edited by E. B. KRUMBHAAR. $1.50 per volume. Paul B. Hoeber.

Essays in the history of medicine presented in a concise and readable form for the general reader. **The Beginnings—Egypt and Assyria.** Warren R. Dawson. ix, 86 pp. **Medicine in the British Isles.** Sir D'Arcy Power. ix, 84 pp.

---

**Photocells and Their Application.** V. K. ZWORYKIN and E. D. WILSON. xi + 209 pp. Illustrated. $2.50. John Wiley & Sons.

The authors have attempted to present an understandable account of the origin and rise of the photocell which will provide the general reader with a practical knowledge of the art of making photocells, and their industrial application.

---

**The Mysterious Universe.** SIR JAMES JEANS. viii + 163 pp. Illustrated. $2.25. Macmillan Company.

Sir James Jeans first sets forth some of the most important discoveries and theories of modern science; and follows them by his own interpretation of these scientific facts, as a basis of his outlook on the universe as a whole.

---

**The Conquest of Life.** THEODORE KOPPANYI. xii + 263 pp. Illustrated. $2.00. D. Appleton & Company.

A popular treatise introducing the intelligent layman to the fundamental concepts of the science of biology, from its early beginnings in Greece up to the present. This is a volume in the "New World of Science Series."

# THE SCIENTIFIC MONTHLY

JANUARY, 1931


## THE NATURAL ELECTRIC CURRENTS IN THE EARTH'S CRUST[1]


By O. H. GISH

CHIEF OF THE SECTION OF EXPERIMENTAL WORK IN TERRESTRIAL ELECTRICITY, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON


THAT electricity and magnetism are closely related has been known for more than a century. It is then logical to expect that the forces which direct the compass, terrestrial magnetism, and the electric phenomena of the earth, terrestrial electricity, are also related in some measure and that a knowledge of one may assist in an understanding of the other. Quite appropriately then both these subjects have been from the start included in the program of research of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, with which department the writer has, during the past eight years, been associated in the investigation of terrestrial electricity.

Terrestrial electricity has two natural major subdivisions, namely, atmospheric electricity, in which the electrical condition of the atmosphere is the matter of chief concern, and the electric currents which circulate within the earth.

Electric currents in the earth's crust may arise from a number of sources. That a steady current flows from the air to the earth in ordinary weather is shown by measurements of the electrical condition of the atmosphere. This is so small that an area of 100,000 square miles receives a little less than one ampere. Currents are generated in parts of the earth by chemical processes which take place there. Such currents have been found associated with bodies of some minerals and have been of use in prospecting for them. No doubt small electric currents arise from temperature differences in the earth. Evidence of such has been found in the vicinity of an active volcano. Electric currents are generated when a portion of the earth is set into motion in such a way as to move relative to the earth's magnetic field. Currents generated in this manner by strong tides have been detected. The electric currents developed in the sea by such ocean currents, as, for example, the Gulf Stream, may play a part of some importance to geology, such, for example, as the concentration of metals just as occurs in electroplating. Sudden pulses of electricity arising from lightning discharges and lasting upwards of one thousandth of a second occur at the rate of about 100 per second for the entire earth. Other but less spectacular discharges from the atmosphere to the earth take place during snow-storms, dust-storms, volcanic eruptions, etc., and give rise to corresponding current in the earth. Currents which stray from electric-power systems, especially electric railways, frequently occur in considerable intensity

[1] Lecture delivered at the Carnegie Institution of Washington, April 15, 1930.

in the vicinity of most cities. These are of some economic concern because of the part they play at times in promoting the corrosion of underground steel structures, pipe-lines, etc. They also become a matter of much anxiety to those who have to do with the operation of magnetic observatories, because the magnetic effects which they produce are often much larger than the phenomena of the earth's magnetism which it is sought to study.

The natural electric currents of the earth's crust of which I wish to speak are, however, quite different in character and origin from any of those just mentioned. These currents are generally referred to by the name "earth-currents." However, that term is also applied to the currents which wander from electric railway systems and which as already mentioned constitute a pest in the investigation of the earth's magnetism and to no less an extent in the investigation of the natural earth-currents. The term "vagabond currents" has also been applied to them, quite justly.

The natural earth-currents, or simply earth-currents, were discovered by the effect which they produced on the first long telegraph lines. It was the practice then, as it is now, to complete the telegraph circuit through the earth. In this arrangement, if natural electric currents flow in the earth, they will be shared with the telegraph line. It was soon noticed that the detecting device then used in place of a sounder would sometimes show irregular and violent motions, which were in no way connected with the signals. After a systematic study of these disturbances on a number of different telegraph lines in England, W. H. Barlow in 1847 found that when one line was disturbed, all were disturbed. He concluded that the common source of these occurrences is a natural electric current in the earth's crust. The occasions on which this phenomenon becomes conspicuous on telegraph lines are now referred to as earth-current storms. These earth-current storms constitute at the present time a recurring source of disturbance to telegraph transmission, producing a

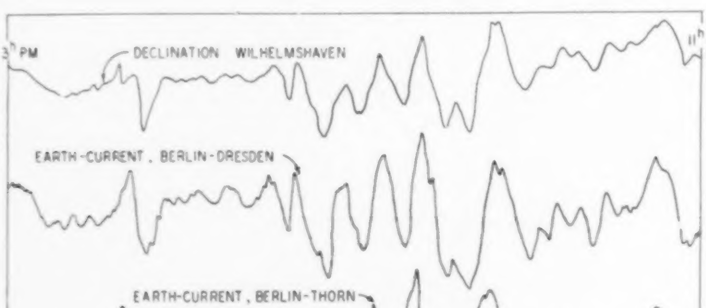



FIG. 1. EARLY RECORDS
OF AN EARTH-CURRENT AND MAGNETIC STORM, NOVEMBER 2, 1884 (AFTER WEINSTEIN).

sort of static and at times injuring the instruments. Although the earth-current which traverses the telegraph line at such times is usually irregular in strength and in direction, yet it is reported on occasions to be sufficiently intense and so steady that messages may be sent without the use of the regular batteries. The earth-current storms are referred to by telegraph operators as "an aurora on the line." Although that appellation implies too much, it has significance. The aurora borealis generally becomes visible farther south during the occurrence of an earth-current storm. On these occasions the earth's magnetism also undergoes changes which are referred to as magnetic storms. These magnetic and electric storms are independent of the weather. The curves in Fig. 1 represent changes that occurred in the compass-direction and in the earth-current at from 3 P. M. to 11:30 P. M., November 2, 1884. The upper curve represents changes in the compass-direction at Wilhelmshaven, Germany; the lower those at Vienna, Austria. The two central curves show the earth-current changes on two telegraph lines, one extending from Berlin southward to Dresden, and the other from Berlin eastward to Thorn. The close similarity between the changes in the earth-currents and those in the compass-direction indicates an intimate relationship between these phenomena.

Scientific interest in the phenomena of earth-currents was stimulated by the possibility of finding therein a solution of the age-old problem of terrestrial magnetism. You will recall that Gilbert in the year 1600 published an extensive treatise in which he proposed to account for the earth's magnetism by considering the earth as a large lodestone. At that time the several types of change which occur in the earth's magnetism were unknown. However, Gilbert's theory was brought into question thirty-four years later, when Gellibrand discovered that the compass-direction at London was steadily changing from year to year. Other changes, such as the magnetic storm already mentioned and certain changes which occur in a regular manner during the day, were discovered later. When Oerstedt announced in 1821 the discovery that an electric current gives rise to a magnetic force, this suggested to Sir Humphry Davy the possibility that natural electric currents may flow in the earth's crust and that variation in their intensity may be the direct cause of fluctuations in the compass-direction. A few years later, 1831, Faraday discovered the principle of electromagnetic induction. According to this principle variations in the earth's magnetism should produce electric currents in the earth. Faraday, although unsuccessful in an attempt to detect such currents, remained convinced that they must exist. This presents an alternative to the possibility suggested by Davy, namely, that the changes in the earth's magnetism produce earth-currents. We shall attempt to see the extent to which each of these two possibilities is realized.

The earlier observations of earth-currents were made on telegraph lines and then chiefly at times of disturbance. The chief advance in our knowledge of this phenomenon has, however, come from systematic observations made on lines resembling telegraph lines and especially constructed and suitably located for the purpose. The method employed in measuring earth-currents is shown in Fig. 2. Electrical connection is made with the earth by means of plates of metal buried in the soil. These plates are connected through a suitable measuring instrument by means of a wire or cable which is carried by the poles. The poles are shown arranged along a straight line, but that is indifferent. The current, or more correctly

the electric force, depends only upon the direction and length of the geometrical line joining the plates. If it were possible to have a number of such lines of equal length but extending in all directions from one position it would be found that the electric force, or potential-difference, measured on one of these would be greater at a given instant than that measured on any of the others. The direction of this line would, of course, be the direction of the earth-current. It is not practicable, of course, to have such an arrangement. However, with two lines arranged about as shown in the diagram, the measurements obtained will enable one to calculate the direction of the current. This then is the scheme that is used in obtaining the measurements which disclose the character of these currents and their variations.

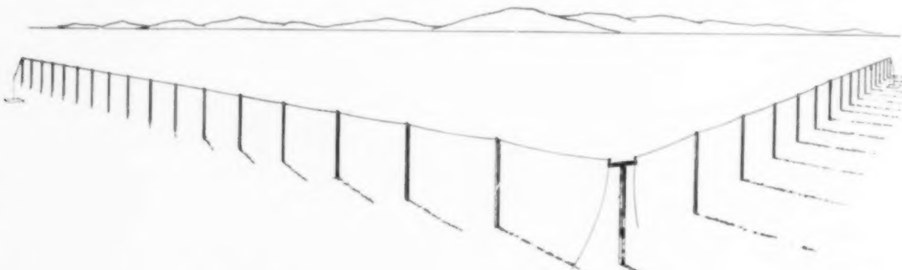



FIG. 2. DIAGRAMMATIC REPRESENTATION

OF THE METHOD USED IN MEASURING THE POTENTIAL-DIFFERENCES WHICH CHARACTERIZE EARTH-CURRENTS.

Systematic observations with arrangements similar to that just indicated have been made at a number of places; some of the outstanding of these are as follows: at Greenwich Observatory, England, from 1865 to 1867; Berlin, Germany, 1883 to 1891 (in this case underground telegraph cables were used, the one extending from Berlin to Thorn, a distance of 262 kilometers, the other from Berlin to Dresden, 120 kilometers); Parc St. Maur, near Paris, where the system for such measurements was installed in December, 1892, and continued for a period of years, when it was necessary, as was also the case at Greenwich, to abandon the investigations because of the intrusion of vagabond currents from electric railways.

At the present time, such systematic observations are being carried out at three places: the Ebro Observatory, at Tortosa, Spain, at about 41° north latitude, which has been in nearly continuous operation since 1910; and at the two magnetic observatories of the Carnegie Institution of Washington, one located near Watheroo in Western Australia at about 30° south latitude, the other near Huancayo in Peru at about 12° south latitude.[2]

The Ebro Observatory is located in

[2] In a letter received after the completion of this paper Mr. R. B. Shanck, of the Department of Development and Research of the American Telephone and Telegraph Company, writes that graphic records of the potential-differences on two telegraph-lines of that company running out of New York have been obtained during the past two years. Some records have also been obtained from Swedish telegraph-lines in recent years. It is also learned that observation of earth-currents has been recently begun at Alibag, India.

FIG. 3. ROAD FROM WATHEROO TO THE OBSERVATORY
THE SAND IS CHARACTERISTIC OF THIS REGION.

southeastern Spain on the border of the level valley of the River Ebro, near the small town of Tortosa and about 50 kilometers from the Mediterranean Sea. Lines somewhat over one kilometer long are used here. The records from this observatory, obtained under the direction of the Jesuit fathers, constitute the longest, nearly continuous series of earth-current data extant.

The Watheroo Magnetic Observatory is located on a level, sandy plain in Western Australia, about 120 miles north of Perth, 50 miles from the western coast and 12 miles from the Watheroo station. Approaching the observatory from Watheroo (Fig. 3), one gains an impression of the character of the surface and of the wide level expanse of the terrain on which this observatory is located. The registration of earth-currents was started here in November, 1923, and has continued ever since with no important interruption. The standard building (Fig. 4) provided at both observatories for housing the recording instruments used in earth-current and atmospheric-electric investiga-

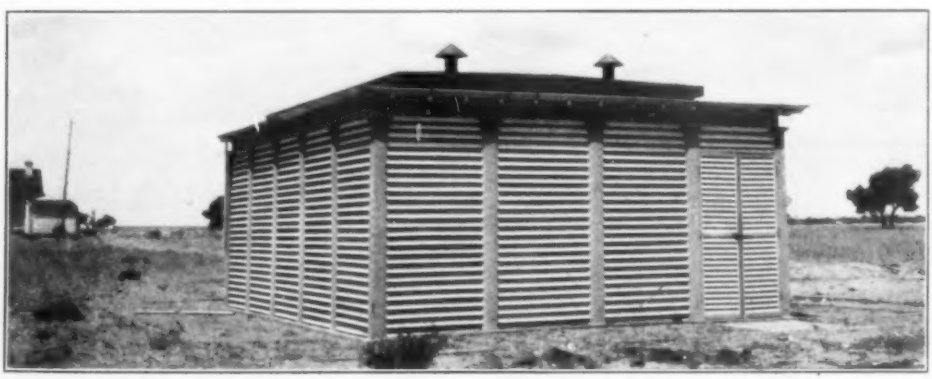


FIG. 4. TYPE OF BUILDING SHELTERING THE INSTRUMENTS
WHICH AUTOMATICALLY RECORD VARIOUS ASPECTS OF TERRESTRIAL ELECTRICITY AT THE OBSERVATORIES OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM OF THE CARNEGIE INSTITUTION OF WASHINGTON.

FIG. 5. LAYING AN UNDERGROUND LINE
AT WATHEROO MAGNETIC OBSERVATORY.

FIG. 6. VIEW OF THE ENVIRONS OF THE HUANCAYO MAGNETIC OBSERVATORY
FROM AN ELEVATION NORTHWEST OF THE OBSERVATORY.

FIG. 7. THE CHUPACO RIVER
NEAR THE HUANCAYO MAGNETIC OBSERVATORY.

tions is a double-walled, concrete structure completely surrounded by a louver. Temperature changes inside this building are small and gradual. The lines used here vary from 1.6 to 10 kilometers in length. A portion of the lines was placed underground in order to ascertain if any appreciable difference occurs between such lines and those placed on poles overhead. The laying of such an underground line is shown in Fig. 5 under the supervision of Dr. G. R. Wait and "Joie."

The Huancayo Magnetic Observatory is uniquely located nearly due south of Washington in the Andes of Peru, at an altitude of 11,000 feet above sea-level. This observatory is also far removed from any industrial sources of disturbance. The site of the observatory lies in a small valley near the confluence of the Chupaco and Montaro Rivers. The observatory appears to the right of the center of the view in Fig. 6. The River Chupaco (Fig. 7) to the west of the observatory is a rapid stream whose bed is cut deep in the general terrain. However, for a considerable expanse about the observatory the topography is quite simple, as will appear in the view in Fig. 8 on approaching the site.

One conclusion coming out of the measurement of earth-currents may be stated at this point, namely, the major part of the earth's magnetic field—the unvarying part—is *not* produced by electric currents in the earth's crust. In all the data available no convincing evidence has been found of the existence of an unchanging component in the earth-current. In other words, the earth-currents are in the main alternating currents, having long periods of alternation. Throughout the following then we will consider only variations in earth-currents, or more correctly, variations in the strength and direction of the force which impels these currents.

This force is very small compared with such electric forces as are a part of our common experience. The force acting between two earth-plates located about 500 miles apart would at undisturbed times be about the same as that which operates your flash-light. At the time of an earth-current storm, however, this force may increase as much as several hundredfold. Some features of a moderate earth-current storm which began at 21 hours Greenwich mean time on July 31, 1929, are shown in Fig. 9. These curves go in pairs. The upper of each pair represents the component of the electric force which would impel electricity westward. The lower one indicates that part which acts toward the

FIG. 8. GENERAL VIEW OF THE HUANCAYO MAGNETIC OBSERVATORY

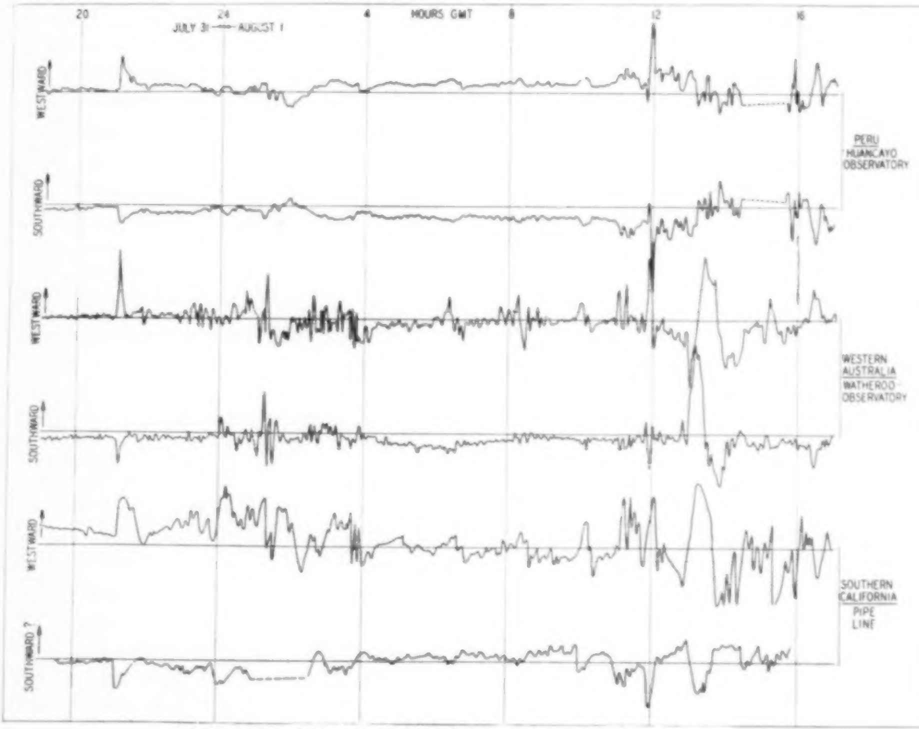



FIG. 9. RECORDS OF EARTH-CURRENT STORM
JULY 31 TO AUGUST 1, 1929, AT THREE WIDELY DISTRIBUTED POINTS.

southward. The upper pair was registered at the Huancayo Observatory; the middle pair at the Watheroo Observatory, and the lower was transcribed from records of the electric current in an oil pipe-line in southern California. These records were obtained in connection with an investigation of the corrosion of pipe-lines made under the supervision of Mr. K. H. Logan, of the Bureau of Standards, without any intention or expectation of measuring an earth-current storm. One very interesting feature of this exhibit is that the sharp commencement of this storm is not only simultaneous in occurrence at these three widely separated points of the earth but also that the direction of the electric impulse is nearly the same everywhere. Other points of similar agreement throughout may be seen, as well as the general concurrence of dis-

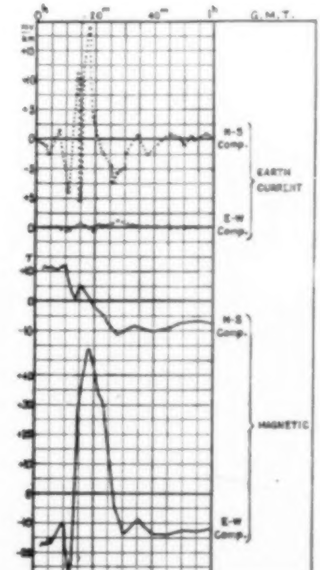



FIG. 10. COMPARISON OF MAGNETIC AND EARTH-CURRENT DISTURBANCES AT WATHEROO.

turbed periods. There can be no doubt but that here is a manifestation of a world-wide process which affects the entire earth at the same instant of time. Aside from the purely scientific interest of this exhibit, it is of importance to investigations of underground corrosion to know the extent to which earth-currents of natural origin, and a part of a world-wide system, may come into play. Magnetic storms also have characteristics similar to those here noted. In fact, earth-current disturbances and magnetic disturbances are so closely related that as an invariable rule they occur in coincidence. An example, observed at Watheroo, is given in Fig. 10. Not all storms, however, have the world-wide characteristic which was displayed by the storm, shown in Fig. 9.

A feature of earth-current storms which is not clearly shown in such diagrams as those just seen is brought out by another method of representation such as is shown in the irregularly shaped diagrams in Fig. 11. The direction and length of each straight-line portion of these diagrams represent the average direction and strength of the changes that occurred in the earth-current in each successive two-minute interval. These diagrams were constructed from observations made by telegraph operators of the American Telephone and Telegraph Company on lines running out from New York City during a storm which occurred on June 17, 1915. Each figure corresponds to a pair of lines whose farther termini are, beginning at the left, Boston and Lansingburg, Lansingburg and Pittsburgh, Pittsburgh and Washington. The approximate direction along which the varying earth-current flows is, at least in temperate zones, in a general north-south direction. This is a matter which is not only of scientific interest, but should be of some importance to the management of telegraph systems, and possibly also in the protection of long pipe-lines from such effects of corrosion as may be promoted by earth-currents.

That the primary source of earth-cur-

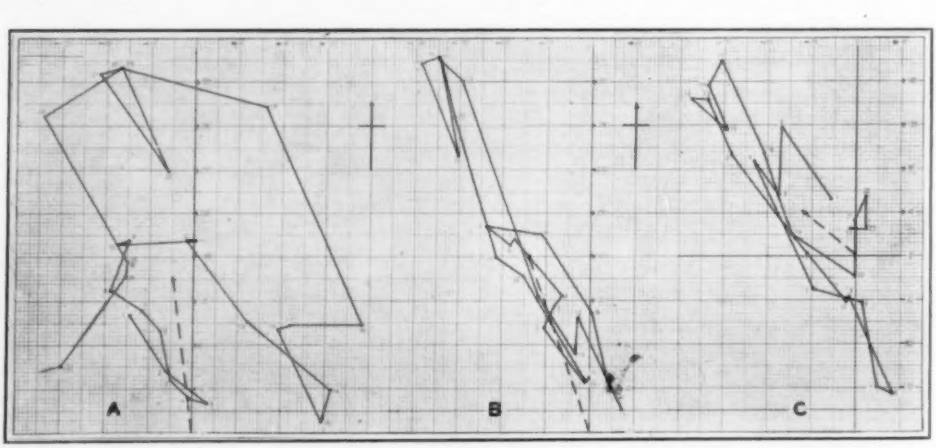



FIG. 11. DIAGRAMS SHOWING THE DIRECTION OF THE EARTH-CURRENT STORM-CHANGES AND MEAN VECTORS (DASHED LINES), JUNE 17, 1915, ON LINES OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY (HORIZONTAL AND VERTICAL SCALES IN MILLIVOLTS PER KILOMETER; *A*, NEW YORK TO BOSTON AND NEW YORK TO LANSINGBURG, BEGAN AT $16^h$ $46^m$ AND ENDED AT $17^h$ $51^m$ G. M. T.; *B*, NEW YORK TO LANSINGBURG AND NEW YORK TO PITTSBURGH, BEGAN AT $16^h$ $56^m$ AND ENDED AT $17^h$ $54^m$ G. M. T.; *C*, NEW YORK TO PITTSBURGH AND NEW YORK TO WASHINGTON, BEGAN AT $17^h$ $04^m$ AND ENDED AT $18^h$ $01^m$ G. M. T.).

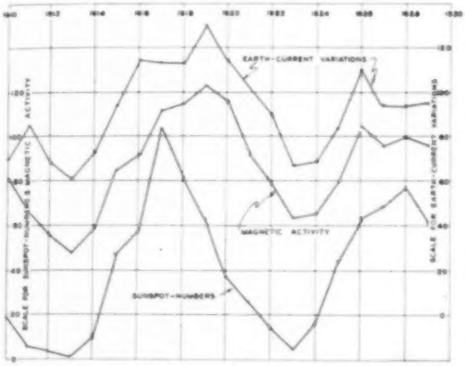



FIG. 12. COMPARISON OF CHANGES IN EARTH-CURRENT VARIATIONS AT EBRO OBSERVATORY, SPAIN, IN MAGNETIC ACTIVITY AT CHELTENHAM OBSERVATORY, UNITED STATES, AND IN SUN-SPOT NUMBERS FROM 1910 TO 1929.

rent storms is some factor seated outside the earth and likely in the atmosphere of the sun is indicated by the manner in which the intensity and frequency of these storms change as the sun-spot number (a number designed to give a measure of the total effectiveness of sun-spots) changes. The extent to which the earth-currents, as recorded at the Ebro Observatory, and the earth's magnetism, as recorded at the U. S. Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Maryland, are disturbed and the manner in which this agitation changes from year to year are shown in the two upper curves of Fig. 12. The close similarity of the changes for earth-currents and terrestrial magnetism is not surprising in view of other evidence which has already been seen, but the manner of change from year to year during the twenty years here represented is sufficiently close to that shown in the lower graph for sun-spots that we may consider this as more than a mere coincidence. Another line of evidence which supports this view depends upon the fact that as the sun rotates it carries about with it the sun-spots. Those which are of sufficiently long life will thus appear on the earthward side of the sun at intervals corresponding to the period of rotation of the sun—about 27 days. Hence if some process in the solar atmosphere, which is announced after a fashion by sun-spots, is the cause of the phenomena of earth-current storms, we should expect these storms also to recur with the same period as is found in the case of the sun-spots. The earth-current and magnetic data of the Ebro Observatory were investigated by Peters and Ennis with reference to such a recurrence. The curves shown in the upper part of Fig. 13 present some results of that investigation. These may be interpreted in the following simple manner. If on a certain date, *N*, the range of variation in earth-currents is distinctly larger than that for the days preceding or following, then the range on a date somewhat less than 28 days later will, in the average, be greater than that on the few days preceding or following. A similar recurrence, as will be seen from the middle set of curves, was also found for low values. Furthermore, in the lower part of the diagram, which represents the results of a similar study of the observations of polar lights made on the *Maud* Polar Expedition, 1922 to 1925, will be

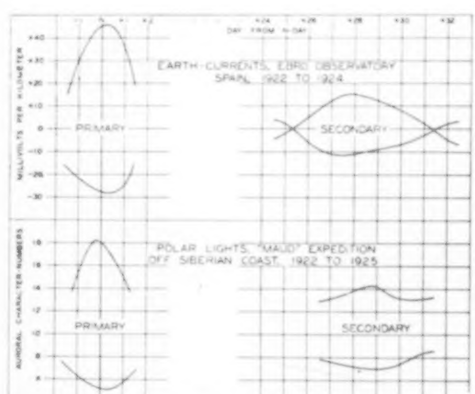



FIG. 13. THE RECURRENCE OF EARTH-CURRENT STORMS AND POLAR LIGHTS IN 27 DAYS.

seen nearly the same type of recurrence in that phenomenon.

Less conspicuous, but no less interesting and important, are variations in earth-currents which proceed in a regular manner throughout the day. These are usually termed diurnal variations. The character of these diurnal variations for the four most extensive sets of modern data available are shown in Figure 14. The two upper graphs apply to the northern hemisphere, namely, Berlin and the Ebro Observatory, and the two lower to the southern hemisphere, namely, the Huancayo Magnetic Observatory and the Watheroo Magnetic Observatory. Although these series do not cover the same period of years, it is not likely that an appreciable difference in the character of the variation represented by these curves would be due to that. A considerable similarity between the curve for Berlin and that for Ebro is evident, and the curve for Watheroo, if reversed, would be very similar to these two. That for Huancayo, however, differs in general type from the other four and at present seems to complicate the general picture. One common feature is that during the daylight hours the currents are more active than at night and that except at Huancayo the northward current is more active than the eastward and flows either away from the equator or towards it, depending upon the time of day. The relative magnitude of the electric force at the several stations is not correctly shown in these curves, it being the purpose here to show the general features of the variation. The forces at the Ebro Observatory are considerably larger than at the other stations. However, from a study of the resistance of the earth to the flow of electricity which has been made at Ebro, Watheroo and Huancayo by W. J. Rooney, as part of the investigations of earth-currents carried on by the Department of Terrestrial Magnetism, it is apparent that the large values recorded at Ebro are in a considerable measure due to the correspondingly

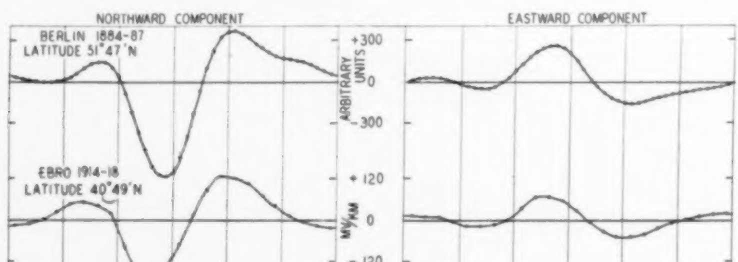



FIG. 14. DIURNAL VARIATION IN EARTH-CURRENT POTENTIALS AT BERLIN IN GERMANY, EBRO OBSERVATORY IN SPAIN, HUANCAYO OBSERVATORY IN PERU AND WATHEROO OBSERVATORY IN WESTERN AUSTRALIA.

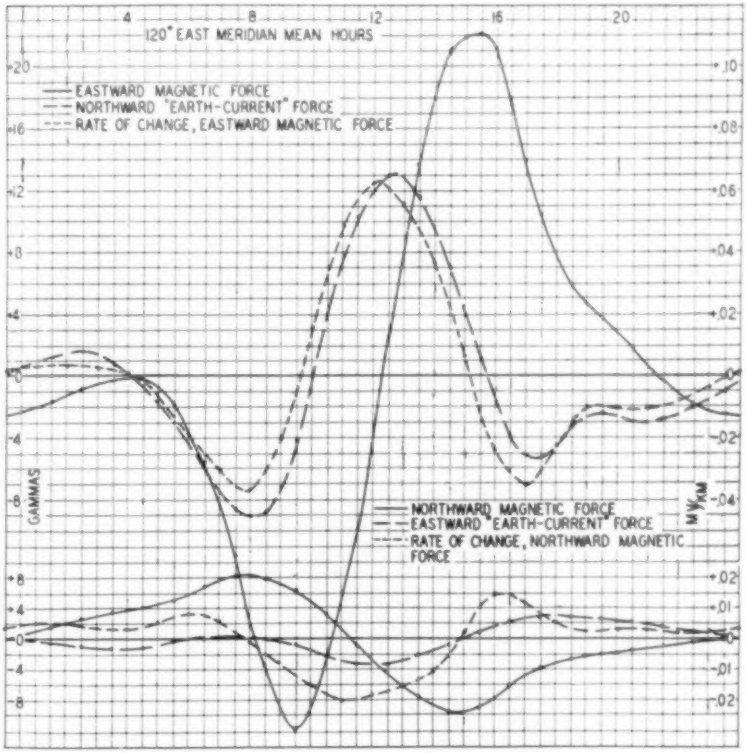



FIG. 15. COMPARISON OF DIURNAL VARIATION
IN EARTH-CURRENTS AND TERRESTRIAL MAGNETISM AT WATHEROO MAGNETIC OBSERVATORY, 1924 TO 1926.

large electrical resistance of the earth at that place. The branch of study covering this aspect of earth-current investigations can not be entered upon here further than to say that in this work means were developed by which the earth has been explored to depths as great as 600 meters (2,000 feet) by employing electrical measurements made on the surface. This method has aroused much interest among economic geologists and geophysicists.

It is, of course, of interest to see how the diurnal variations in earth-currents compare with the corresponding variations in terrestrial magnetism. In the chart shown in Fig. 15 data from the Watheroo Observatory are thus compared. The solid curve in the upper group represents the diurnal change in the eastward magnetic force, and that drawn in long dashes represents the corresponding change in the northward-flowing component of the earth-current. In the lower group the continuous curve again represents the variation in the magnetic element, this being that component which acts toward the north. The curve constructed with the long dash represents the variation in the eastward-flowing component of the earth-current. In neither set of curves is much resemblance to be found between the magnetic and the earth-current changes. The relation thus appears quite different from that seen in the case of storms. If the curve for either magnetic component

and that for the electric component which flows in a direction at right-angles to the former had turned out to be similar, then the possibility that the magnetic changes are produced primarily by the earth-currents could have been considered. This possibility is, however, obviously excluded by this evidence. The alternative which is suggested by Faraday's principle of electromagnetic induction, namely, that the magnetic changes produce the earth-currents, would require that the earth-currents are greatest at the time when the magnetic force is changing most rapidly, disappearing when the magnetic force ceases to change and changing in direction when the magnetic change alters from a decreasing to an increasing force. That these conditions are approximately fulfilled for the upper set of curves is readily seen. However, the extent to which this relation exists is shown best by the curves drawn in short dashes. These curves represent the change which should result during the day if the earth-currents arose in the simplest possible way from the magnetic variations. These calculated curves are in much closer agreement with the actual curve than is that for the magnetic variation. However, some disagreement is in evidence, so that it may be unsafe to conclude that the magnetic changes alone are active in producing the earth-current changes. It is in fact certain that the earth-currents, even though directly produced by the magnetic changes, will have a reaction which affects the measured values of the earth's magnetic force. The strength of this reaction depends upon the internal structure of the earth, and when the phenomena of earth-currents are more completely known we may hope to use these in exploring the deep structure of the earth.

Conspicuous changes in the amplitude of curves such as those just shown occur from month to month during the year. If the amplitude of these, or the range in the diurnal variation, is charted for each month of the year, the character of this change with season will be best shown. The chief feature in such

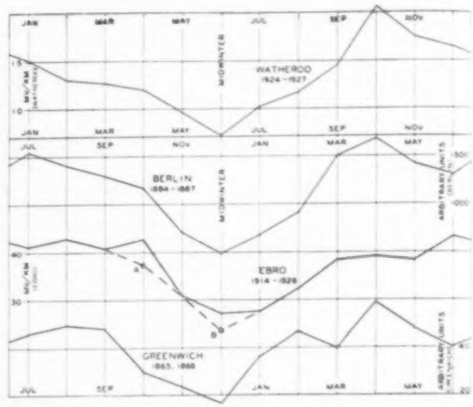



FIG. 16. SEASONAL VARIATION IN DIURNAL RANGE

OF NORTHWARD COMPONENT OF EARTH-CURRENTS AT WATHEROO, BERLIN, EBRO AND GREENWICH.

charts (see Fig. 16) is that the lowest values occur at all these observatories at mid-winter and the maximum shortly after the vernal equinox. This variation with season of year suggests that the sun also plays a rôle in the diurnal variation of earth-currents.

You have seen here samples of the evidence which suggest relations between the changes that occur in earth-currents and those that occur in the earth's magnetism, for those irregular changes known as storms, for the diurnal variation, that type of change which occurs in a regular manner during the day, and for the variation from year to year in a cycle corresponding nearly to that of the sun-spots. We have also reviewed evidence which shows that some phenomena of both earth-currents and the earth's magnetism are in some way related to the position of the sun and to the occurrence of polar lights. We have noted that in the case of magnetic and earth-current storms the relation is more nearly that which would be ex-

pected if the change in earth-currents were the cause of change in the earth's magnetism, whereas for the changes during the day it would appear more nearly correct to assume that the magnetic changes produce the earth-currents. You will now, no doubt, desire to know what has been done in the way of developing a theory, or perhaps better, a unified picture of these phenomena. In this connection the diurnal variations and the storms should be considered separately. The theories which are offered in explanation of the diurnal variations differ considerably from those suggested for the explanation of the earth-current and magnetic storms. We will first briefly sketch the theory of the diurnal variations. Two theories of this phenomenon are receiving consideration at the present time. Both these theories have the following aspects in common: (*a*) That the process which more directly affects both earth-currents and terrestrial magnetism in a regular manner throughout the day is seated high in the earth's atmosphere; (*b*) that the condition in the atmosphere at this height which makes this process possible is produced by radiations coming from the sun. These radiations acting upon the molecules of this rarefied atmosphere produce electric carriers in extraordinary abundance so that this part of the atmosphere becomes a good conductor of electricity. As to the particular radiation which predominates in producing this effect, there is no general agreement. The ultra-violet light from the sun, or a corpuscular radiation consisting of either positive or negative electrified particles or both, shot from the sun with high speed, and the penetrating or cosmic radiation have been variously considered.

On the one theory, the region of the atmosphere thus capable of transporting electric currents of considerable intensity is subject to great winds. Thus we have a good conductor in motion relative to a magnetic field, namely, that of the earth. In this manner great electric whirls are generated in the high atmosphere. The magnetic effect of these whirls of electricity extends to the earth and induces there earth-currents which in turn give rise to another magnetic effect. The magnetic change measured at the earth's surface, therefore, on this view arises from these two sources, electric currents in the atmosphere and electric currents in earth. The portion of the atmosphere directly under the sun is much more affected than that on the dark side of the earth, and thus as the earth rotates this portion of the atmosphere affects successively the different parts of the earth and can thus obviously give rise to a regular change throughout the day. To account for the winds, however, or the required motion of the high conducting atmosphere presents the great difficulty for this theory. Some evidence that winds of great velocity do exist there is found in the drift of meteor trails.

According to the other theory great whirls of electricity in the atmosphere would not occur, but rather, each electric carrier under the action of the earth's magnetism moves in a spiral. This is equivalent to a small magnet. Each electric carrier acts in this way and in a certain orderly fashion, so that without any general electric circulation a magnetic condition arises which at the earth's surface is quite similar to that which would result from the other theory. From this point on, then, the phenomena would proceed in the same way under both theories. The latter theory has the advantage that it is unnecessary to assume the existence of the intense winds required for the former. In this theory, however, a greater abundance of electric carriers is required in the high atmosphere, and it is here that this newer and simpler theory meets its greatest difficulty. Too little is yet known about the constitution of the high atmosphere to be able to firmly establish either of

these theories. However, the present-day development of radio presents a new means of exploring the high atmosphere. It now seems likely that phenomena observed in connection with the transmission of radio waves will provide facts which are needed to decide some disputed points in the theories of the origin of earth-currents and the variations of the earth's magnetism. The common relationship between certain radio phenomena and changes in terrestrial magnetism and earth-currents arises doubtless in part from the fact that this conducting region of the atmosphere has a common influence on all these phenomena, so that a study of each will assist in the understanding of the others.

Whatever the reality underlying the diurnal variations may be, the theories just outlined at least serve as a sort of aid to the memory by providing a visualization of these phenomena for the earth as a whole. The system of currents which J. Bartels, of Germany, has calculated would be required in the atmosphere to produce the observed diurnal changes in the earth's magnetism is shown in Fig. 17. The arrowheads and the course of the curves indicate the path of the current, and the concentration of the curves represents the density of the current. Over the sunlit hemisphere two great whirls will be seen, one on either side of the equator. These are of greater regularity and density than the circulations shown over the other hemisphere. The total current estimated for one of the daytime whirls is 100,000 amperes. This diagram will serve also to give a picture of the general character of the system of currents in the earth's crust at ordinary undisturbed times.

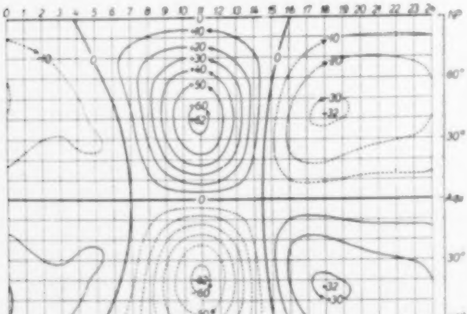


FIG. 17. THE SYSTEM OF ELECTRIC CURRENTS

WHICH, ACCORDING TO ANALYSES OF BARTELS AND CHAPMAN, WOULD BE REQUIRED IN THE HIGH ATMOSPHERE TO PRODUCE THE AVERAGE DIURNAL CHANGES IN THE EARTH'S MAGNETISM.

Earth-current storms and magnetic storms should, in view of the close relationship shown by many observations, find a common explanation. Various attempts have been made to provide a theory or some model which would account for magnetic storms, but in these the phenomena of earth-current storms have been generally neglected from consideration. The result of this one-sided development is that all theories of magnetic storms fail to account for the principal phenomena of earth-current storms, and until they do, they can scarcely be considered seriously, even should they satisfactorily account for all the principal phenomena of magnetic storms, which they do not. All the recent theories of magnetic storms invoke electric currents which are assumed to arise in the atmosphere high above the earth, currents which depend upon processes seated in the atmosphere of the sun. As to the manner in which these currents are produced, there are three views extant. The corpuscular theory holds that streams of electrons shot from the sun at speeds nearly that of light, under the action of the constant part of the earth's magnetic force, are in part caused to converge in a zone near the magnetic poles and are in part made to encircle the earth in the rare atmosphere high above the equatorial belt. The former give rise to polar lights and some magnetic impulses, and the latter constitute

the direct source of the major aspects of magnetic storms.

The induction-theory assumes that the high atmosphere is subject to a complicated system of winds or circulation which, if that region of the atmosphere be a sufficiently good conductor of electricity, will generate electric currents there because of the motion of this conductor relative to the earth's magnetic field. Both the winds and the conductivity in that part of the high atmosphere which comes into consideration here may vary suddenly under the action of radiations from outbursts on the sun, radiations which both heat the atmosphere and increase the number of electric carriers there. The sudden changes in the currents thus produced would in turn cause magnetic changes at the earth's surface.

In yet another very recently proposed theory the somewhat forced assumptions which appear in the two older theories, namely, the high-speed electric corpuscles and the complicated system of winds, are replaced by devices which appear more plausible. In this, reasons are given which make it seem likely that by the action of the ultra-violet light from the sun some atoms are blasted from the portion of the atmosphere located about 450 kilometers from the earth and are carried thousands of kilometers farther out before they are ionized. When ionized, the earth's magnetic force combined with the force of gravity tends to cause these to circulate about the earth's axis, especially over the equatorial belt, thus producing in turn a magnetic change at the earth's surface corresponding to the world-wide magnetic-storm effect. Some, however, drift along the magnetic lines of force and return to lower levels near the poles where they give rise to other aspects of magnetic storms and produce the polar lights. Relatively large changes occur in the intensity of the ultra-violet light emitted by the sun and thus give rise to the irregular fluctuations recorded in magnetic instruments. This theory has very attractive features but many details require further study. In all these theories the world-wide part of a magnetic storm is considered as caused by electric currents in the high atmosphere over the equator. This would require that the electric currents in the earth's crust flow in an east-west direction at such times, especially in lower latitudes, but so far as observations go these currents tend rather to flow in a north-south direction, as has already been seen in Fig. 11. Another point of disagreement between theory and fact is that the time relationship between the earth-current changes and the magnetic changes, as noted earlier in this discussion, is that which should be found if the former were the cause and the latter the effect.

At the present stage of our studies, it appears that many of the magnetic changes which occur at storm times are produced by the earth-currents, that in general the currents characteristic of storms flow, roughly speaking, either north or south and at least in some cases traverse the earth, roughly speaking, from pole to pole, as though electricity were supplied at one pole and removed at the other. There are, however, grave difficulties in the way of such a view. The solution of the riddle presented by earth-current and magnetic storms will doubtless be furthered by more intensive study and observation of earth-currents and especially by observations in the far north (or south). Do the splendors of the polar lights signalize a terrific bombardment of the polar atmosphere by electric particles traveling at a speed sometimes so great that this bombardment reaches the earth and thus by supplying electricity in an irregular manner give rise to earth-currents at times of storm? This is one of the questions which we hope further studies of earth-currents will assist in answering.

# PROBLEMS OF ANTIQUITY PRESENTED IN GYPSUM CAVE, NEVADA[1]

By Dr. CHESTER STOCK

BALCH GRADUATE SCHOOL OF THE GEOLOGICAL SCIENCES, CALIFORNIA INSTITUTE OF TECHNOLOGY

## Introduction

Strikingly real as the material evidence of the life record of the past frequently is the vividness of that reality is in large measure dependent upon the satisfaction which one experiences in apprehending organisms of a remote period as once living creatures. Nowhere is this better exemplified than in those noteworthy occurrences where remains of mammalian types, presumably long extinct, have come down through time, exhibiting not only skeletal parts but also the epidermal structures, excrement and occasionally the viscera in a remarkable state of preservation. Curious though it may seem our views regarding the geologic antiquity of this type of material are frequently but dimly defined.

It is now a little over thirty years since the Swedish explorer Nordenskjöld, learning of the discovery of a curious piece of hide near Last Hope Inlet, Patagonia, was led to investigate the famous Eberhardt Cave of Ultima Esperanza. Excavations in the deposits by Nordenskjöld, Moreno, Erland Nordenskiöld and others brought to light an unusual collection of material including remains of man and of several types of extinct

[1] Based on a paper presented before the National Academy of Sciences, Pasadena, September 23, 1930.


FIG. 1. INDEX MAP

Showing location (×) of Gypsum Cave, Nevada.

FIG. 2. VIEW LOOKING NORTHEAST

SHOWING ENTRANCE TO GYPSUM CAVE AT BASE OF LIMESTONE FACE (IN SHADOW) ABOVE CAMP OF SOUTHWEST MUSEUM-CALIFORNIA INSTITUTE. THE SPARSE VEGETATION IN FOREGROUND INCLUDES SEVERAL SPECIES OF CACTI, CREOSOTE BUSH, *Krameria*, CATCLAW AND NEEDLE GRASS.

mammals. Among the specimens were fragments of skin, hair, horny sheaths of claws and excrement found definitely associated with skeletal remains of large mammals. The materials, exhibiting characters totally unlike those of any living animal of South America, were later determined to be of the extinct ground sloth *Glossotherium*.

So real did the ground sloths become in view of the remarkable preservation of their remains that the story of an actual existence of these animals—the mysterious mammal of Patagonia—was received with considerable credence. Later explorations in South America failed to substantiate the story, but the facts concerning the occurrence and associations of *Glossotherium* are regarded by many as furnishing at Ultima Esperanza indisputable evidence of the presence of man and of mammals generally regarded as characteristic of the Pleistocene or Ice Age.

The recent discovery of Gypsum Cave in southern Nevada by Mr. M. R. Harrington, of the Southwest Museum, brings to light a cavern occurrence and an entombed life record presenting many features similar to those which characterize the South American cave. Located in the foothills of Frenchman Mountain, by road 20 miles east and slightly north of Las Vegas, this cave is readily accessible at an elevation of approximately 2,000 feet. Deriving its name from the presence of huge and beautifully formed selenite crystals, Gypsum Cave has resulted from differential solution in Paleozoic limestone and is now of large size and of irregular shape (see Fig. 4).

The presence of several cultural stages and the unusual preservation of an animal and plant record in the deposits furnish an almost unprecedented opportunity for the archeologist and paleontologist. At the invitation of the South-

west Museum the California Institute has been fortunate in sharing equally in the investigation of the site, concerning itself particularly with the stratigraphic succession and with the interpretation of the fossil or subfossil animal and plant remains. While the recent explorations have not been completed certain striking aspects of the deposits and of the specimens recovered are worthy of delineation as furnishing perhaps a typical example of the problems encountered in broader studies of the succession of Quaternary life in America.

FIG. 3. VIEW LOOKING SOUTHWEST FROM CAVE ENTRANCE
SHOWING DESERT COUNTRY EAST OF FRENCHMAN MOUNTAIN, NEVADA. GYP PEAK IN DISTANCE TO THE LEFT OF FIELD CAMP OF THE SOUTHWEST MUSEUM-CALIFORNIA INSTITUTE.

### Deposits

While each of the several more or less clearly outlined chambers of the cave exhibits an interesting stratigraphic record, perhaps the clearest cross-section of the deposits is that revealed beneath the floor of the principal chamber (Room 4). Doubtless the sedimentary succession shown here by trenching furnishes an important key to the interpretation of the deposits found elsewhere in the cave. Situated 65 feet below the entrance to the cavern, this chamber is approximately 120 feet long by 65 feet wide (Fig. 7). Entrance to it is gained toward the bottom of a broad, inclined surface of angular limestone rubble.

At a depth of 14 feet large limestone blocks were encountered. It is possible that these represent the rock floor on which the sediments accumulated. The strata above this consist principally of angular limestone fragments, the individual fragments frequently being a fraction of an inch in diameter. Much of the material may have been derived from the walls and ceiling of the cavern. Intercalated in the series are irregularly bedded sands, doubtless deposited under water. At the top of the deposit of fragmental limestone occurs a gypsiferous layer followed upward by sloth dung. The latter exhibits in places a matted and trampled appearance; in others the individual clods retain for the most part their original form. Occa-

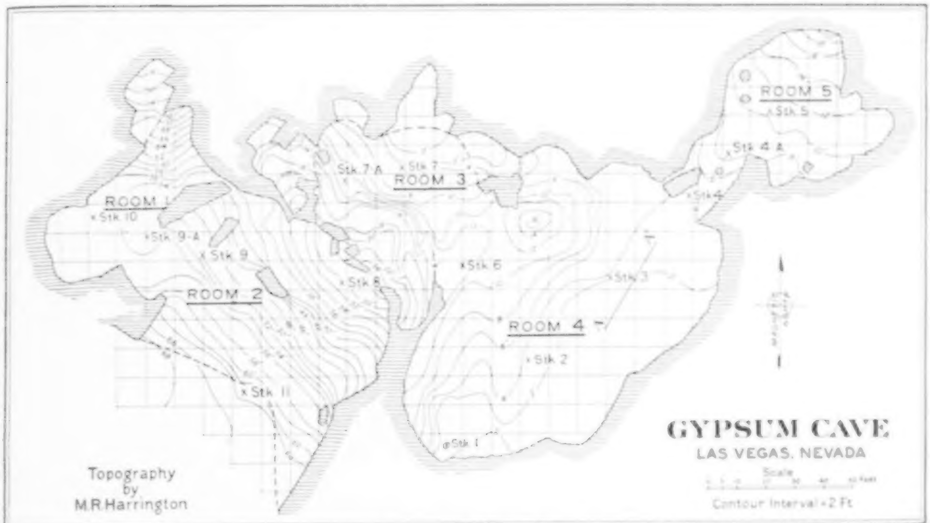



FIG. 4. TOPOGRAPHIC MAP OF GYPSUM CAVE

A–A′, LOCATION OF SECTION THROUGH UPPER DEPOSITS IN ROOM 4.

sionally specimens are found in which the outer shell of a clod remains intact but the inside has been consumed, perhaps by rodents. In places also the dung is burned or charred while elsewhere it has a remarkably fresh appearance. Scattered through this accumulation is the dung of other mammals. The layer of dung has a maximum thickness of at least 26 inches, although laterally it may thin to a few inches. Intercalated in it may be found a second gypsiferous layer, usually a few inches thick. At several localities stalagmites have formed, and it is interesting to note that where these are found the dung is absent.

Piled on the floor in Room 4 is a large mass of limestone débris derived presumably in part from the ceiling as a rock fall and in part from rock slides. Evidence obtained from the depositional record would appear to indicate that slide or fall material accumulated also during the formation of the dung layer. The extent and distribution of the dung material suggests, moreover, that the animals responsible for its accumulation had ready access to this portion of the cavern and were represented by a number of individuals or frequented the chamber for a long period of time.

A well-defined dung layer has been recorded by Harrington as occurring also in Room 1, immediately to the left of the entrance to the cave. It is a fair assumption perhaps that the period of accumulation of the material in this

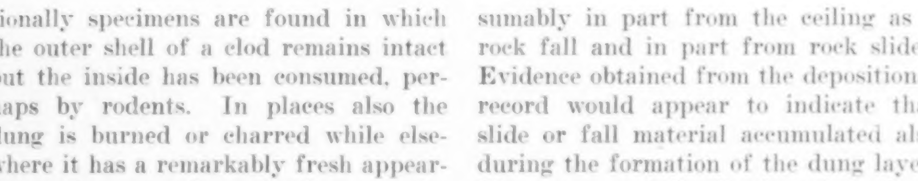



FIG 5. CROSS-SECTION OF UPPER DEPOSITS

AT A–A′, IN ROOM 4, SHOWING POSITION OF ATLATL DART-POINT AND BONES OF EXTINCT MAMMALS. FROM FIELD SKETCH BY J. E. THURSTON. GYPSUM CAVE, NEVADA.

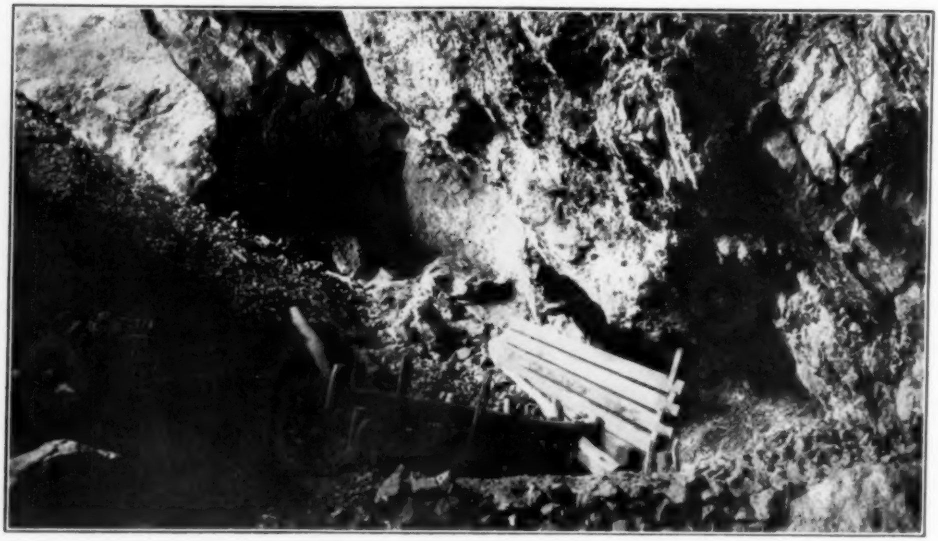


FIG. 6. VIEW LOOKING ACROSS LOWER END OF ROOM 2
ENTRANCE TO ROOM 4 IS LOCATED OFF LOWER RIGHT-HAND CORNER OF PICTURE. GYPSUM CAVE, NEVADA.

chamber coincides with that of dung formation in Room 4. Considerable sheep manure is found toward the top of this layer. Above it occurs limestone detritus to a thickness of six or more feet, followed in turn upward by a layer from which Pueblo and Basket-maker cultures have been obtained.

### SOME ORGANIC REMAINS FOUND IN THE DEPOSITS

Mammalian remains have been encountered in the lower strata which have been penetrated in Room 4. In the sands intercalated in the deposit of angular limestone fragments at a depth of ten feet were found incomplete skeletal elements and teeth of camel and horse. Thus far, however, the ground sloth remains are not known to occur below the overlying dung layer. The latter is in large part made up of the excrement of the ground sloth *Nothrotherium*. A well-preserved specimen of this material is shown in Fig. 9. Superficially these clods are like the excreta of the South American genus *Glossotherium*, figured by Santiago Roth (compare Figs. 8 and 9), although the former are somewhat smaller in size.

No attempt has been made as yet to identify all the plant remains which constitute the bulk of the clods and of the trampled manure in Gypsum Cave. The scatological studies will furnish valuable information concerning the food habits of the nothrotheres and it is to be hoped also of the floral environment which prevailed in the vicinity of the cave during the period of existence of these animals.

The better preserved skeletal and epidermal structures of these ground sloths occur in the dung layer. No complete skeleton of *Nothrotherium* has been found, but a number of elements have been recovered. It is significant that most of the skeletal remains belong to this ground sloth. Fig. 10 shows a nearly complete hind foot of *Nothrotherium* in which several of the bones exhibit on the surface bits of dried flesh or tendinal strands. Moreover, the

horny claws of the terminal phalanges remain intact. Small fragments of the hide appear to be also preserved. This material is now thoroughly desiccated and shrunken, but reveals on the surface occasionally the base of many hairs. There is no evidence of the presence of ossicles in the skin as in the mylodont ground sloth *Glossotherium* of Eberhardt Cavern. Many strands and occasionally small masses of hair have been found in Gypsum Cave. These frequently have a yellow or tawny color, although hair of a brownish or reddish brown color has been noted. Whether all the hair found thus far belongs to *Nothrotherium* has not been determined.

While the skeleton of *Nothrotherium* has been known by rather complete remains described from the Brazilian caves and from the asphalt deposits of Rancho La Brea in California, only recently has direct information become available regarding some of the external characters of this creature. Professor Lull has described[2] an unusually complete skeleton with remains of epidermal structures and a food ball from a guano deposit at Aden Crater, New Mexico.

A native of the southern continent, *Nothrotherium* reached North America apparently during Pleistocene time. Closely related types occur in middle or lower Pliocene deposits of western North America, and it is possible that the nothrotheres were among the first mammals to arrive from South America when the two areas were joined, after a prolonged separation, in late Tertiary time. An illustration of the skeleton of *Nothrotherium* is shown in Fig. 11.

Skeletal remains of at least three additional mammals of relatively large size occur in the dung deposit. It is not surprising to find the mountain sheep (*Ovis*) recorded in view of the frequent occurrence of sheep dung. The presence of a slender-limbed camel is indicated by several broken skeletal elements. This type differs in structural characters from the large camel (*Camelops*) recorded at Rancho La Brea and may be closely related to a slender-limbed camel (*Tanupolama*) described from the Mc-

[2] R. S. Lull, *Mem. Peabody Mus. Yale Univ.*, Vol. 3, pt. 2, 1929.

FIG. 7. VIEW OF ROOM 4

FROM POINT AT ENTRANCE TO ROOM 5. SLOTH DUNG LAYER WITH BONES OF EXTINCT MAMMALS EXPOSED IN TRENCH ON LEFT; LIMESTONE DÉBRIS ON RIGHT. GYPSUM CAVE, NEVADA.

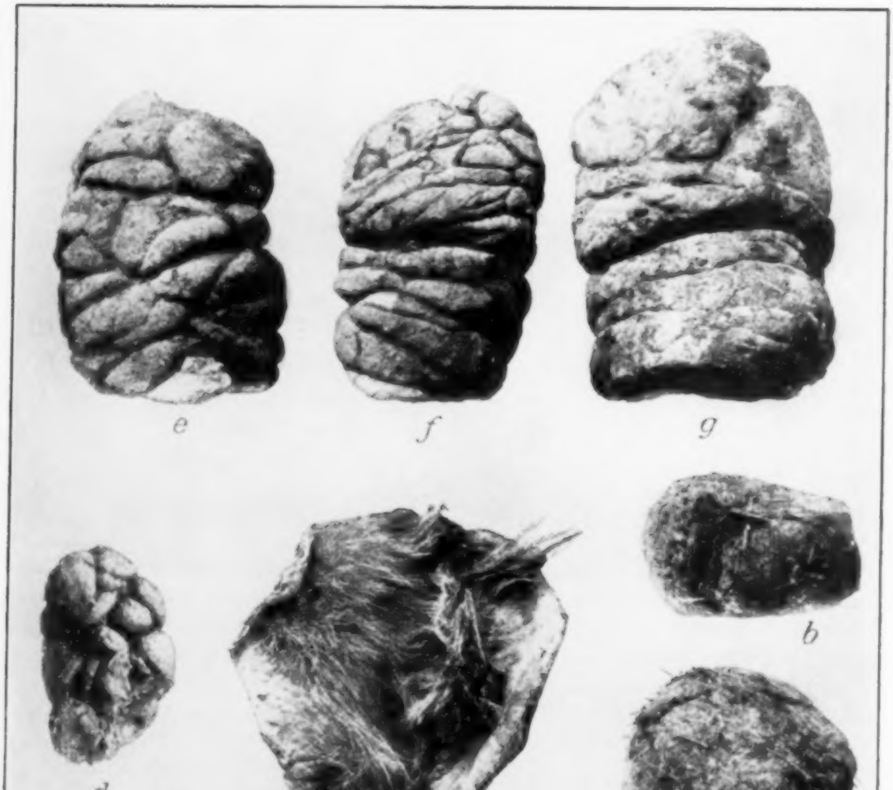



FIG. 8. GROUND SLOTH AND ASSOCIATED REMAINS

From Eberhardt Cavern, Last Hope Inlet, Patagonia. Figs. *a*, *e*, *f*, *g*, skin and excrement of ground sloth *Glossotherium*. Approximately × $\frac{1}{8}$. After Santiago Roth.

FIG. 9. DUNG OF EXTINCT GROUND SLOTH *NOTHROTHERIUM*

APPROXIMATELY × ⅙. NOTE PLANT REMAINS AND DRIED MUCOUS COVERING. GYPSUM CAVE, NEVADA.

Kittrick deposits, a second asphalt accumulation of Quaternary age in California.

The relationships of the fourth type to be mentioned, namely the horse (*Equus*), have not been definitely determined particularly with reference to the known species of horses from the Pleistocene of western North America. Materials found in the dung include not only skeletal parts but portions of the horny hoofs as well.

No evidence has appeared as yet indicating the presence of the larger and more formidable types of carnivores known to have existed in Pleistocene time. While the smaller predatory forms are represented by skull and skeletal materials in the collections, the great lion, the saber-tooth cat, the short-faced bear and the dire wolf remain unrecorded.

## PROBLEMS

Two problems of major importance are presented by the Gypsum Cave occurrence, namely:

(1) Was man coexistent with some or all of the animals occurring in the deposits?

(2) What degree of antiquity in Quaternary time can be ascribed to the mammalian fauna and more particularly to those types found in the dung layer?

A consideration of the first question involves a critical analysis of the evidence furnished by artifacts present in the deposits and by the stratigraphic relationships of the human cultural stages to the occurrence of extinct mammals. The archeologist, seeking to extend the early history of man in Amer-

FIG. 10. RIGHT HIND FOOT OF *NOTHROTHERIUM*

VIEW FROM ABOVE, APPROXIMATELY × ¼. NOTE PRESENCE OF HORNY SHEATHS ON CLAWS. GYPSUM CAVE, NEVADA.

ica, is fortunate in finding at Gypsum Cave material evidence of past cultures and of extinct animals as well as a sequence in the stratigraphic occurrence of this material. Thus far human skull and skeletal remains have not been found. While important archeological material has been secured in all the chambers the cultural stages recorded by Harrington in Rooms 1 and 4 need only be considered for purposes of the present discussion. The interpretation of these results must await a more detailed study of the objects themselves and a more intensive investigation of the occurrence, but some of the noteworthy facts have been commented upon by Mr. Harrington.[3]

In Room 1, as already mentioned, a trench through the strata revealed at the top unmistakable evidence of a Pueblo culture and of the Basket-makers. Some distance below this horizon occurred a well-defined sloth dung zone with an intercalated layer of gypsiferous material. Immediately below this dung were found fragments of charcoal, although the dung itself is undisturbed. Here also was encountered a worked stick.

In Room 4, definitely embedded in a gypsiferous layer intercalated in a zone of burnt dung and ashes, occurred a stone dart-point of an atlatl or throwing stick. Within two feet of this object and in the same layer was also found a limb bone of the ground sloth *Nothrotherium*, while in the layer of burnt dung above and not more than six feet distant from the dart-point were the charred and broken limb bones of the slender-limbed camel.

The close proximity and stratigraphic position of the artifact and the bones of extinct animals are of critical importance in determining the possible contemporaneity of man and these mammals. While the presence of a single dart-point may be accounted for on the basis of later intrusion, it is of significance to note that additional cultural material was found under similar circumstances elsewhere in the cavern. A sufficient number of artifacts has been recovered to permit Harrington to state[4] that the cultural stage includes objects of cruder type than those of the Basket-makers.

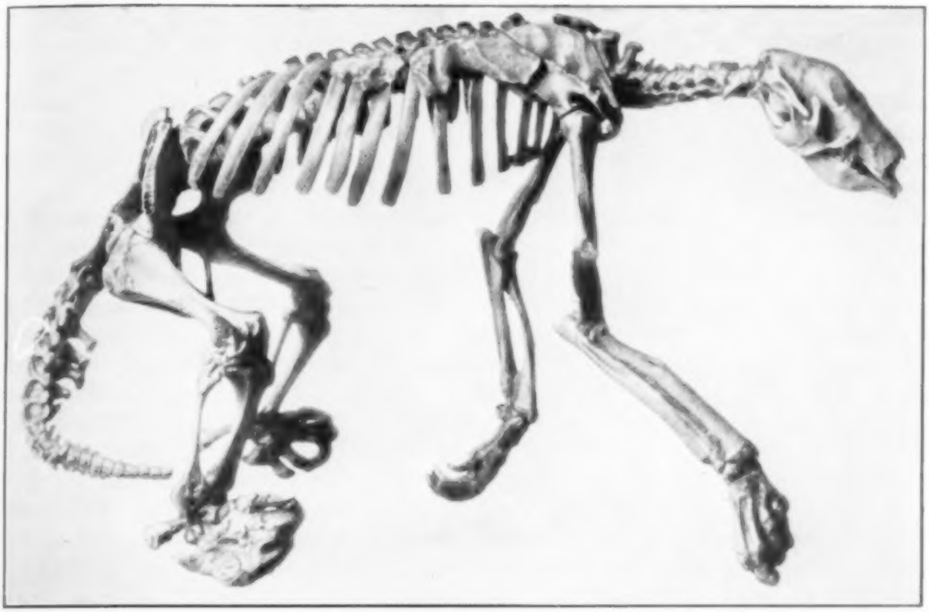
The stratigraphic relationships of the cultural material to the animal remains may indicate either a contemporaneity of man and types of mammals now extinct or a record of a past mammalian life on which has been superimposed or intruded a record of early man in America. Should the latter be accepted ultimately as the explanation of the unusual occurrence at Gypsum Cave, the period intervening certainly would appear to be of relatively short duration, measured at most in terms of a few thousands or perhaps even hundreds of years.

To the student of American Quaternary life the determination of the relative antiquity of mammalian assemblages known from within this period is of no less importance than the establishment of irrefutable evidence of an association of certain extinct types with early man. It may be readily conceded that the two questions are after all intimately related. The unique facts concerning the occurrence in Gypsum Cave lend special importance to the locality in a study of this problem.

Within recent years much attention has been directed to the Quaternary land assemblages of North America and to the chronological sequence of these faunas. Noteworthy contributions to this field of inquiry have been made by that venerable student of Pleistocene life, Dr. O. P. Hay. In an attempt to

[3] M. R. Harrington, *The Masterkey*, Southwest Museum, 4 (No. 2): 36–42, 1930.

[4] M. R. Harrington, *Scientific American*, July, 1930, p. 36.



—*Courtesy of the Peabody Museum, Yale University*

FIG. 11. SKELETON OF *NOTHROTHERIUM*

SIDE VIEW, APPROXIMATELY × 1/14. REMAINS OF EPIDERMAL STRUCTURES CAN BE SEEN ON SKULL, SHOULDER BLADE, RIBS AND FEET. ADEN CRATER, NEW MEXICO.

evaluate the field evidence with a view to reaching a satisfactory judgment as to the relative antiquity of a particular terrestrial assemblage of the Quaternary the student has recourse presumably to several criteria. Among others, perhaps the following may be indicated: (1) Occurrence in glacial or interglacial deposits; (2) specific relationships to existing or to other fossil or subfossil assemblages; (3) changes in distribution of types since period of deposition; (4) climatic changes as determined from (*a*) past and present distribution of organisms and from (*b*) associated plant remains; (5) type of preservation.

With the exception of the stratigraphic criterion stated in (1), the criteria given above appear to have special application to the occurrence at Gypsum Cave. In some instances, however, as for example the criteria stated in (2), (3) and (4*a*), the soundness of the judgment reached as a result of their application depends in large measure upon the size and completeness of the fauna. Care certainly must be exercised in drawing conclusions where the basic facts reveal an incompletely known fossil or subfossil mammalian assemblage. With further excavations in the cavern doubtless other types will be added to the list already on record.

Careful study of the plant remains preserved in the dung may offer important suggestions as to the type of flora which prevailed in the vicinity of Gypsum Cave during the period of existence of the ground sloths and associated forms. Were it determined, for example, that the plants fed upon by these creatures do not differ in type from those now found in the xerophytic flora of the region there would be no special reason for postulating climatic conditions notably different from those which

prevail there to-day. In view of the close proximity of the cavern occurrence to lake basins in southern Nevada, whose history may be related to that of Quaternary Lake Lahontan, the climatic evidence derived indirectly from the flora may be of importance in establishing the period of occupancy of the cave in relation to certain stages through which these lakes have passed in Quaternary time.

A relatively late age of the dung accumulation and of the embedded animal remains is not of necessity implied by the unusual preservation of the material. It is conceivable that under the peculiar conditions prevailing in a dry cave the epidermal structures and excrement of *Nothrotherium* may have undergone but little change, even though the period of their accumulation was long ago. On the other hand, it must be admitted that the type of preservation may with equal right be regarded as evidence indicating that the remains date from a late period of time. Moreover, had this region witnessed major fluctuations of climatic conditions since the period when the cave was occupied by the ground sloths it is difficult to believe that the remains would now exhibit the remarkable preservation which they do. If the plant remains comprising the dung are ultimately found to represent species which now form part of the living flora of the arid Southwest, this evidence and that presented by the excellent preservation of the material may indicate a remoteness of this life stage from the time of the last glaciation sufficient to place it well within the Recent division of the Quaternary.

# THE WHALE SHARK OFF HAVANA HARBOR

By Dr. E. W. GUDGER

AMERICAN MUSEUM, NEW YORK CITY

and Dr. W. H. HOFFMANN

LABORATORIO FINLAY, HAVANA, CUBA

THAT *Rhineodon typus*, the whale shark, the largest of its tribe, is found in the Straits of Florida is attested by four captures on the coast of the peninsular state and by two off the harbor of Havana, Cuba. Of the Florida fish, the first (18 ft. long) came ashore three miles north of Ormond Beach on January 25, 1902. The second (38 ft. in length) was taken near Knight's Key in May, 1912. The third fish (31 ft. "over all") was captured in the Bay of Florida, June 10, 1919. The fourth (and to date the last) specimen from Florida waters was secured at Marathon, 16 miles below Long Key, on June 9, 1923. The three captures near Havana will now be described in some detail.

The first of these, the fifth record for the Straits of Florida, was made on November 20, 1927, at Jaimanitas, a fishing village about five miles west of the mouth of Havana harbor. This fish and its occurrence in this region we have recorded elsewhere.[1] It was an adult male 32 feet in total length, its greatest girth was 18 feet and its estimated weight was nine tons. The weight of the liver was said to be 900 pounds, and of the heart 43 pounds. The body of the fish was reported to be six feet deep, and the small of the tail at the base of the caudal fin was so large that a tall man could scarcely encircle it with both arms. An idea may be gotten of the

[1] *American Museum Novitates*, no. 318, 7 p., 4 figs., 1928.

FIG. 1. THE FIRST HAVANA WHALE SHARK

PARTLY OUT OF WATER AT JAIMANITAS AS SEEN IN LEFT-FRONTAL VIEW. NOTE THE HARPOON IN THE LEFT GILL REGION. NINE MEN ARE PERCHED ON ITS BACK.

FIG. 2. RIGHT LATERAL VIEW OF THE FIRST HAVANA *RHINEODON*
SHOWING THE BLUNT HEAD, MEDIAN FINS, LATERAL KEELS AND THE UPPER LOBE OF THE TAIL FIN.

immense size of the fish by reference to Fig. 1, a front-lateral view showing the huge fish with nine men on its broad back.

An even better idea of the size of this great shark may be had from inspection of Fig. 2 in which the fish is shown in lateral view. Here may be seen the longitudinal keels or ridges running from the head region backward along the side. Crossing these at regular intervals are vertical white or yellow bars. The intersection of keels and bars gives a checkerboard-like appearance to the sides of the fish. This is accentuated by the large white or yellow spots set in the middle of each square. This is plainly seen in Fig. 5 showing in detail a part of the side of the fourth Florida specimen. The local Cuban name of the fish is *pez dama,* in allusion to this. Now *pez* means fish and *dama* lady, but the

FIG. 3. THE SECOND HAVANA WHALE SHARK
ON THE SHORE AT COJIMAR. NOTE THE WOODEN FRAMEWORK ON WHICH IT IS LYING, THE HARPOONS IN THE HEAD REGION AND THE THIN STEEL ROPE CONFINING THE RIGHT PECTORAL. THE WEDGE-SHAPED DARK REGION ON THE HEAD IS A SHADOW CAST BY ONE OF THE ONLOOKERS.

Cubans do not mean "lady fish" by this appellation, for *dama* also means checkerboard. Hence when it is locally called *pez dama,* this means "checkerboard fish" to the hearers. The blocked-off sections of skin with their enclosed large round spots certainly do resemble a checkerboard with the checkers in the center of each square.

In a head-on view of the first fish, Fig. 4, one may get a clear idea of the cavernous mouth, large enough to take in a grown man. Now the term shark is synonymous with voracity and ferocity, and the mouth (especially of a large specimen) is supposed to be full of large sharp cutting teeth. In the lower jaw of this 32-foot specimen the tooth band is fairly visible. The closely set backwardly pointing teeth are only about one eighth of an inch in length, and, unlike the dental apparatus of most sharks, can function for retention only.

As for ferocity, the whale shark is everywhere reported as sluggish and stupid—this has been markedly true of all the Florida specimens. This Havana shark allowed a boat to be "nosed" against him while a harpoon was being thrown into his left gill region. Even after being harpooned, he made little or no disturbance but merely dragged the boat around after him for some 20 hours until finally, weakened by loss of blood, he allowed himself to be towed to the shore.

The second Havana whale shark was captured on March 10, 1930, off Cojimar, a seaside town about five miles east of the mouth of Havana harbor. We have made a faunal record of it elsewhere.[2] This fish like the other was also a male and but slightly larger (about 34 feet over all) than the first. It or another fish had been seen off Cojimar for some three years previous, and had been appropriately dubbed "El Elefante." So well known was it that a merchant of Havana had subsidized a crew of fishermen to hunt for it, and had provided them with specially made tackle—harpoons, ropes and buoys.

The manner of capture of the Cojimar

FIG. 4. NEARLY HEAD-ON VIEW OF THE FIRST HAVANA *RHINEODON*

SHOWING THE CAVERNOUS MOUTH WITH THE TOOTH BAND OF MINUTE TEETH IN THE LOWER JAW. THE HARPOON SHOWN IS THE ONE USED IN ITS CAPTURE.

[2] *Science,* 71: 639–640, 1930.

fish was different from all other methods known to us for the taking of the whale shark. The fishermen in two gasoline launches easily approached the sluggish fish, and, manipulating a thin steel cable by means of long bamboo poles, managed to put over the head and around the body of the fish a double slip noose. The small wire rope was then drawn tight about the body of the fish, confining the pectoral fins and materially hampering the activity of the fish. This shark was captured in the open sea about a mile from shore where the water was deep enough to enable the fish to escape by diving. To hinder his submerging and to locate him if he did dive, two steel petroleum drums were affixed to the steel rope. Thus held more or less at the surface, *Rhineodon* was attacked with harpoons and also about 50 shots were fired into him from a Winchester rifle.

Thus held both by the lasso around the pectorals and attached to the drums,

FIG. 5. A PORTION OF THE SIDE OF THE WHALE SHARK

SHOWING THE CHECKERBOARD ARRANGEMENT OF KEELS, CROSSBARS AND SPOTS WHICH LEADS THE CUBANS TO CALL IT "PEZ DAMA"—CHECKERBOARD FISH.

and by harpoon lines fastened to the boats, *Rhineodon* was towed and driven into Cojimar Bay. The fish does not seem to have offered any material resistance to all this, and finally died from loss of blood about 24 hours after he was attacked. But although at the shore, it was tremendously difficult to get the fish out on the beach. Forty men tailing on ropes were unable to drag him out, and this was finally effected only by getting him on a raft-like structure and hauling this and the fish ashore by means of a winch or crane.

Fig. 3 shows the second Havana whale shark on its wooden skids or framework drawn out on the beach. Plain to be seen are the encircling wire rope and the two harpoons in the region back of the head. The color markings show plainly save that over the head is a wedge-shaped black shadow which gives the head a bizarre appearance. The very small right eye is seen low down on the side of the head, just in front of the piece of wood on which the body lies. Unfortunately we have not been able to get any other photographs of this specimen.

From the data presented above, it seems very probable that other whale sharks will be taken in the Straits of Florida and in adjacent waters. Rumors reach us of various great sharks seen in Florida waters, some of which may possibly have been whale sharks. An unconfirmed newspaper account tells of one seen this spring off Bimini, Bahamas. And for waters off Havana harbor, the fishermen speak of various great sharks, some spotted, seen at various times of the year. We know practically nothing of the habits of *Rhineodon*, but it seems to come near the shore and hence into shallow water at those times of the year when the sardines are shoaling. This agrees with accounts coming from a scientific correspondent in the Seychelles Islands, western Indian Ocean. There seems to be no doubt that it feeds on these small fish.

# REFLECTIONS ON THE STRUGGLE FOR EXISTENCE

By Dr. GEORGE J. PEIRCE

PROFESSOR OF BOTANY AND PLANT PHYSIOLOGY, STANFORD UNIVERSITY

If any excuse is needed to justify resurrecting this hackneyed phrase it can be found in the fact that the phrase is by no means as meaningless in reality as it is in the minds and mouths of most. To those who lead the sheltered and secure if modest lives of Academe there may come affliction, trial, bereavement, hard work, enforced economy, monotony and protractedness of dress, and the various other ills of which they grumble; but their next meal depends upon their own immediate exertions only as they may voluntarily and for pleasure be carrying lunch or whipping a trout stream. This next meal is not the fruit of the earnings of the next odd job; and the night's rest comes elsewhere than on a park bench, in a "flop house" or in an ash barrel. They are a protected people. Connected with educational establishments the parts or the whole of which may find the annual statement "in the red," they find it so because authority permits living beyond the corporate income, knowing the need, the opportunity, the obligation, and confident of not too long deferred recognition and readjustment. They do not go to the bank to find that their salary check has not been deposited on the date due. Like other salaried persons who are parts of honorable and successful organizations, they can count on the monthly, quarterly, annual income. This is very different from the independent in business, financed as an individual and not indebted to stockholders common or preferred. The independent in business, balancing his books at the end of a stormy period, may find that for himself, when all current debts are paid, there is nothing left to compensate him for his year's labor, thought, anxiety, nothing to support himself and his family. From this professors are a protected people. There are no uncertainties of trade with them, once they have made the general bargain as to rank in salary; though, in the academic world, as elsewhere, energy, worldly wisdom, executive ability and persistence yield their expected returns.

Professors are even more protected than this, for they know that unless they are worse than flagrantly idle, unless they are flagrantly vicious according to the usual standards, they will almost certainly be continued in their secure if modest incomes. They are not obliged to maintain a quota of sales, or to do any other stipulated task, lest they lose the agency for Fords or forestry or forensics, in their district. There is no struggle for existence: they survive anyway, except in those rare instances which are investigated by the committee on academic freedom of the professors' union. The reason and the results of this protection may retain our interest for a moment.

In academic life there is no single gauge by which to measure usefulness or attainment, for there are so many kinds of work to be done. The teaching of undergraduates may be done with such high and single purpose, and such charm and dignity, that the bachelor of arts carries through life affectionate respect for the professor who showed him all these, with his Greek; or it may be so done that most bachelors remember only the amusing vagaries of a teacher, the contagion of whose enthusiasm may be caught by but few, but which inspires and guides graduate students to seek

to penetrate the depths. The conduct of academic business by a distinguished teacher may be such as to clog the works, while a generally unknown man may act with such tact and promptness that one is unaware that every one is comfortable, that the library has the books one needs (where did they come from? who ordered them?), that equipment and material are ready when required. This is good housekeeping. The coordination and cooperation of undergraduates, graduates, departments, staff, alumni and the general public are not the product of chance. Some one man in the university brings it about, continuing and increasing it. But such sympathetic appreciative understanding does not come about as the result of ways unchanged since the Universities of Alexandria and Bologna were founded by a process of aggregation. The colleges and universities do not meet the changing needs of a changing world except as interest and thought are applied to the new problems with no less earnestness than to archeology and paleontology.

So, with no such single simple gauge of individual and corporate usefulness and attainment as the sales quota or the cash dividend, the universities find themselves protecting dead wood from the results of decay at the same time that they are fostering and promoting the most precious products of civilization, its scholarship and its youth, increasing their usefulness and their satisfactions. A university is a grotesquely inefficient organization, but a vastly effective one. It is the former because the phenomenon so general in the world of nature, the struggle for existence, is excluded from it; and it is the latter for the same reason. I have in mind an average professorial garden, one in which the work is done by loving and not hired labor, in which there may be weeds, but in which also there are unusual things, plants or arrangements. The yields a commercial florist might find quite inadequate; but pleasure, interest, health and even some biological knowledge (such as acquaintance with snails) are regularly produced. In that garden there is and there isn't a struggle for existence; for the gardener removes what he will, the survivors are not the survivors in any ordinary struggle for existence, they survive according to the intervention of the god (or the goddess) of their little world. Our universities are like our gardens, planned for a little more than the available income, not standardized like pianos, but each possessing its own quality like an organ. And in our universities, as in our gardens, plants which are not doing their utmost may nevertheless justify their retention. Productive scholarship, zealous research, efficiency, leadership and all the other rubber stamps of our vocabulary yield on reflection to charm, character and clear thinking—the gifts of God and the product of man, the examples more potent than precepts in academic as well as in so-called practical life.

Brought up where the New England conscience originated, I have often wondered, since coming West, why work should be considered so virtuous. One must work to keep alive where weather, soil or subsistence are inadequate. Does not the New Englander therefore make a virtue out of a necessity? And is not this perhaps the origin of all virtue, morals and religion? Why does not the world owe us a living? Do not those organisms, human and other, succeed best which are not independent, self-supporting, self-nourishing?

While granting that analogy is not argument, as a biologist I automatically turn to the world of nature for answer to some of my human problems. If I correctly apprehend the plant and animal world, I see one peopled with unnumbered kinds of living beings.

They range in size from the invisible to the monstrous; in behavior from the motionless of the sea-anemone and the oak to the swiftness of horse and swallow; from complete, independent, individual, self-contained existence to the parasitism of the invisible inhabitants of the body cavities of their hosts. They vary from the persistent shyness of the rabbit and the snail to the boldness of the blue jay and the squirrel. I see all sorts of associations, all sorts of competitions, all sorts of selfishness, and no manners. The chipmunk, favorite of children and of many physical adults, becomes a secondary tenant of my Sierra camp when melon seeds and other delicacies useless to man are available. When Mr. or Mrs. Chipmunk comes alone, or brings the children, they present a charming, not to say edifying, spectacle; but let Mr. and Mrs. come together, the children will wisely stay at home (whether of their initiative or their parents' I do not know), and there is no evidence of gallantry or of wifely devotion, there is no conjugal felicity, there is no partnership, no sharing in prosperity, there is only the struggle for melon seeds, often accompanied by a cuff or a snip and a squeak, and that too in spite of the fact that Mrs. Chipmunk may be carrying Mr. Chipmunk's unborn children, and necessarily be less swift and graceful than in her younger days. Perhaps Mr. Chipmunk reforms and takes on some manners when Mrs. Chipmunk is confined, but he (and she) certainly have none before and after that event.

And what of the children? Begotten, *nolens volens*, they come into the world together, without choice of parentage, degree of prosperity or social status. Fed they are for a time, and warmed also. The world owes and provides them a living, but it doesn't last long; and even amongst themselves the little ones struggle, for more milk, more warmth, more comfort and protection. Shortly they are themselves scurrying for melon seeds and running away with them, with a cuff or a snip and a squeak for their fellow strugglers against death by starvation.

In the behavior of my chipmunk neighbors I see no sentiment, no altruism, no code of morals or ethics, no parental care beyond the brief period of helplessness, no filial devotion, no care for the old and feeble. There are no feeble chipmunks, and I have never recognized an old one.

Furthermore, the chipmunks are completely democratic. Human democracy has been variously defined as a state offering equal opportunity to all, or, as I heard a scoffer say once to the major "minor prophet of democracy," a condition of equality among autocrats. Human democracy was invented by the brighter sufferers in order to equalize the struggle for existence among nationals of the same state or country. It was a step away from individualism, and yet the individual has flourished under it as never before. The complete and perfect democracy of the individual, as one sees it among chipmunks and many other animals, is not the aim of political or social leaders among men. These are in fact promoting class or social democracy instead, equalizing opportunity by reducing social or political or economic differences. And certainly the aim is not equality but advantage, the benefiting of the promotor and his or her following. The socialist wishes socialism and the social revolution only so long as his own self, family or class will be benefited thereby. Does one encounter a rich socialist, yet a sane one, who advocates the destruction of the system of property? I have yet to see one, although I have met several persons who still consider themselves radicals, socialists, progressives or what not but who, when given the opportunity, so con-

ducted themselves that they were mistaken for conservatives, reactionaries, stand-patters.

In a perfect personal democracy, where all are created free and equal, and are entitled to life, liberty and the pursuit of happiness, there must be inequality if the members of the democracy are to thrive, for a democracy without leaders is merely a free for all, a struggle, without perspective, for existence. In the chipmunk world, so far as I know, there is equality of a sort, for the chances of getting melon seeds or grains from the wild grasses are the same for all chipmunks in the same vicinity; and there is inequality, for the swiftest, most agile, most intent and most inconsiderate will get the most seeds or grains. Such an individual will have the best chance to survive the winter, for he will be better fed, better fatted and better furred than his fellows; and he may have a "bigger and better" family in the following spring. Because of their individualism, however—or as New England used to have it, "Every man for himself, and the Devil take the hindmost"—this bigger and better family does not constitute itself a leader in chipmunkdom, the democracy remains a pure democracy, with equal opportunity to all, equal necessity to sink or swim, live or die, survive or perish.

In the competition with the other animals seeking melon seeds, grains or nuts one sees an Ishmaelitish struggle, each against every other and every other against him. There is never more than momentary protection for any one, never more than momentary advantage of any sort. Greater weight, strength, agility and determination may characterize one of two animals fighting for "a place in the sun"; and if the fight be like those chemical reactions which run to the end, there will be only one survivor. The same advantages may be possessed by individual chipmunks over other individual rodent competitors, with the same result. Such competitions may result in individual initiative, originality, astuteness and downright intellect of most astounding sort. If I could tell wild animal stories as I have heard them from the lips of the bronzed, brave and unsentimental members of the United States Biological Survey, you would marvel with me at the skill enabling a killer wolf, for example, to maintain himself or herself on the range for months in spite of bounties, traps, guns and mounted men. Survival is the fruit of sheer intellectual ability and attainment, of competition whose only limit is the capacity of the contestants, whose end is the limit of endurance of one or both parties, and in which both brain and brawn are needed and used.

In favor of the killer wolf a considerable amount of sentiment might be aroused in this community, though not in Utah, because the wolf after all was already established in the land, with his own high standard of living, his considerable degree of comfort, not to say elegance, his intellectual quality as witnessed by his small family and important social connections. What justification is there for white men attempting to penetrate a territory in which Indians, wolves, chipmunks and grasshoppers had attained such a balance of power as to constitute a fairly commodious system? Did necessity or the desire for otherwise unattainable advantage drive the Pilgrims to the bleak coast of New England? Did necessity or desire for advantage compel the westward movement? Was the desire to abolish slavery, or the desire to equalize labor and other costs of production, the fundamental cause of the struggle which did not equalize wages in the North and the South, but which has made of our country the most powerful

economic unit to-day? Is it fear of economic competition or of undue crowding in our empty spaces which is the inspiration of our objection to Asiatic immigration?

In the modern human struggle for existence, for comfort, for prosperity and for peace of mind we have gone very far from the simple individual democracy which is a free for all in a sparsely settled area. Organization and leadership have destroyed the individualistic condition, and we have attained a greater degree of prosperity for many, and indeed greater comfort and safety for all, than would otherwise have been possible. Combination among equals may lead to more successful dealing with competitors of other sorts, but it promptly leads also to competition within the combination, and out of this internal competition come leadership and subordination, cooperation, discipline and obedience. Equality prevents success in the struggle for existence and destroys itself sooner or later.

Why there must be the struggle for existence is obvious enough, for one need realize only that the world is too full of things, living and lifeless, for the individual to survive without effort. Out of the struggle for existence have come combinations among animals which have placed some far up in the scale of existence, while those which have persisted in pure democracy, in individual equality, have developed but little more than the plants. One may point with pride to the forest as an example of a successful pure democracy; but so are a poison oak tangle and a colony of gelatinous algae successful in a way, but only in a very limited way.

Among ideals there is a corresponding struggle for existence. We have seen that under the conditions prevailing on the earth to-day pure democracy is impracticable. We have abandoned it in fact, though not in fancy, for we have accepted the ideas of combination and leadership. To these ideas of combination and leadership we have attached altruistic ideals in order to control combination and leadership within such bounds that, while national or local human society is successful in competition with its neighbors, the components of the society may have a fair share in the benefits. We want and submit to leadership so long as we consider it good for ourselves. We choose leaders, or have them chosen for us, according as we vote for president or install a college president. And according to our tastes, what we enjoy, the principles we were provided with and perhaps still retain, we are citizens of the republic, not calling our duty done when we grumblingly pay taxes and criticize the administration, municipal, state and national; or we are wards of the commonwealth as truly as if we were Indians or incompetents.

In so-called practical life there have developed media of exchange—money, position, invitations and visiting cards. In academic life we have a little of these, and some others. Perhaps the most acclaimed of these others are deanships and research. Deanships are like certain plants, thriving and prolific only under quite suitable conditions.

The history of the American universities records great growth in attendance, the development of organizations designed to give to their students the utmost advantage of residence, but with an increase in income not equal to the costs of increased numbers and the increased living expenses of their staffs. American youth has resorted in great numbers to the universities and colleges in the belief that in them it would find advantage, temporary or enduring, proportioned to the expenditure of time and money. Without our specifying whether this advantage is social, scholarly, vocational or amusing, it is gen-

erally accepted as adequate. The numbers have come, and the necessity of caring for them has resulted in organization which has produced advancements more rapid than scholarship alone could win. These promotions in rank and salary have been awarded in recognition of the need of the hour and of the executive capacity of the individual. The phenomenon has been so general in America that the young scholar would have been blind or hopelessly stupid not to recognize that the surest road to academic preferment and economic amelioration lay in this direction rather than in research. Pure research as a means of livelihood was not safe.

We are engaged in our respective subjects of study and teaching because they are what interest us most; we are more curious about them than about any other subjects of human inquiry; but we have, in addition, interests and obligations which, if we are conscious and conscientious, we also feel that we must attend to. The man who marries and has children has duties commensurate with his growing privileges. The man married or unmarried who lives in a commonwealth, as distinct from a benevolent academic autocracy, has obligations as a citizen. These are not limited to the periodic casting of a dissatisfied ballot for candidates for public office too often only a little less inadequate than their rivals. The man, therefore, who is primarily interested in philosophy, philology or finance finds himself a citizen, a husband and father, a bread-winner. Unaccustomed in this new country to the old world conventions and conveniences of marrying wealth and employing servants to care for household and laboratory drudgery, the young man who contemplates a life devoted to research realizes that it is attainable only at great sacrifice, not necessarily exclusively his own. Even if he have an adequate income by gift, bequest or marriage, the academic establishment of which he is a part is unlikely also to have an income adequate to the provision of such persons as will so relieve him of drudgery that he will be free to pursue his own taste without thought of others. Conditions generally in this country, then, are economically, socially and conscientiously against the scholar who would prefer research to the writing of income-producing books, to the rendering of extra-academic professional services for pay or even to the filling of intramural academic office.

The young scholar may even ponder the question whether the curiosity which he feels about nature or society or human history is in itself of finer quality and more deserving of support by his fellow citizens than other men's hobbies, for which they themselves pay. "The honor and danger of the trusts to which we are called"—to quote the prayer which is heard on academic occasions in one of the universities of the Far West—imply an obligation so impressive that one may modestly wonder whether one is fulfilling it in self-indulgence. Collecting Indian skulls may be no more honorable than collecting Indian baskets. Collecting "data" may be no more valuable than collecting postage stamps. From stamps, data, baskets and skulls one may derive personal satisfaction; one may learn the ways of human and of other nature; one may discover laws of development, distribution and design, but one will stop at one point or another, short of the highest goal, according to the limits of imagination, ambition and conscience.

Research, then, is not in itself more than the vision of those who pursue it. It is worthy or unworthy according to the ratio of the cost to the value of the product. It is like all other human things, fine or selfish, a carving or just chips. And yet, because we have so

often heard research extolled as the scholar's highest aim and highest service, conscience pricks us if we do not make some other scholarly effort than the mastery of some field of knowledge and the training in it of those who resort to us for guidance. I assume that there is not one of us who is not curious about this or that "unknown," who is not desirous of satisfying that curiosity, who would not gladly devote himself to the satisfaction of such curiosity, who would not make his contribution to knowledge if his obligations permitted. To see one's duty fairly, in its true proportions, in its true relations to the university of which we are parts as well as employees, and to those about us; and then to do one's duty, that is what each one desires, and for the most part what each one does. Research is but one duty, one ideal. Devotion to it may be as misguided as entering a cloister. To be a saint or a scholar may be very useless!

As we pass in this western world from the pioneer stages, in which the white man has successfully displaced in the struggle for existence the former occupants of the territory which he has invaded, we approach the conditions prevailing in the older countries of our world. In the oldest countries, in the crowded conditions of Asia, in the less old and less crowded conditions in Europe, we see what is before us, unless man learns to effect a new balance in the civilization which he is making. In the civilizations of which ours to-day is the modern replica, essentially the same balance has always prevailed. Honors, rewards and power have been given always to the non-producer, first to the man of might, the militarist, later and to-day to the man of means, the plutocrat. We have always attempted to do what is contrary to nature. We light the dark hours, we build against gravity; man, a land animal, travels upon and in the sea; and now he attempts to traverse the air. He scorns time and distance as facts, and reduces them to their lowest terms. He ignores his absolute dependence upon food and drink, and crowds together so that neither he nor his neighbors can grow or capture food. By the bounty of nature he survives—destroying the producers of food. He fells the forest for fuel, housing, furniture; he converts the grazing spaces to golf courses or other less amusing uses; he makes the land so valuable that it can not be planted to food crops; he goes where rain is scanty, and he makes the soil naked so that it washes away. He demands food and drink and, with niggardly hand and unthinking mind, plans what he is pleased to call "farm relief." So far as I can see, the world will never be safe, for democracy or anything else, until man recognizes his absolute dependence, not upon raw materials, mineral resources, coal, oil or other sources of usable energy, but upon the two things which he can not make, and one of which it would seem that he never can make in sufficient amount to satisfy even his minimum requirements. The clothes moth makes its own water by its own physiological processes; but who would pattern after the clothes moth even if he could? But no animal makes its own food. In this land of white collars we reward those who can buy them. We do nothing for the men who grow the linen, the cotton and the starch to make them serviceable and, according to our esthetic standards, fitting. We compensate, more or less uncertainly, the man who grows luxuries on land for which he paid $1,000 an acre. We force the wheat farmer to produce bread at such a price that he must grow it so far from the market that his own wage, being what is left after paying for freight, handling, storage and the percentages of every handler between himself and the con-

sumer, is so small that a grain-broker would consider it negligible. Our food must be grown on the cheapest land if we are to buy it in sufficient quantities. The cheapest land is that most remote and hence least desired for other uses. This fact entails the long and costly haul to market, the repeated handlings by man or machinery, the risks and rents in transit and storage. The milling would cost roughly the same anywhere and at any time. The agricultural problem—and this is the crux of the problem of the struggle for existence —is due to our having emphasized and rewarded everything but the essentials of our existence.

In this funny world of ours, in this amusing country of ours, we have long discussed the device of tariffs. We have invented octroi, customs dues and finally duties for the protection of infant industries. We have succeeded so remarkably that Fords and safety razors are in the hands of almost all of us. But breakfast should follow the use of the razor, and lunch and dinner must be supplied to the driver of the Ford. Bread, meat and milk are furnished in return for wages the very lowest. This has always been the case, but it is necessarily so only because of our misconceived civilization, a civilization the honors and rewards of which are given to the least necessary parts, a broadening civilization the pyramid of which we have built upside down. The reason for the turning of youth from the farm to the town is the miserable, the delayed, the uncertain pay for producing what we can not get along without. And if, in the struggle for existence, the farmers fail, our civilization will have destroyed itself. We grant, in debate, that agriculture is the foundation of prosperity and even of existence, but we do nothing to preserve it, we do everything we can to undermine it. We charge our colleges of agriculture with failure to produce farmers. Have our medical schools failed to produce physicians and surgeons, our law schools failed to produce attorneys? We reward their products with the pay they require. Our theological schools have failed. Why? For the same reason that our colleges of agriculture have failed, namely, that the compensation for training and knowledge in these two fields is so inadequate. We still see some young men of brains and character, as well as devotion, entering upon the ministry to souls; and perhaps some young men of brains and character and devotion entering, with inherited capital, upon the ministry to stomachs. But without capital how can one start to produce wheat or corn or meat? If the capital be only the land, and the young man be unwilling to use wife and children as laborers, how far can he go? He must buy seed, implements and transport for his harvest, and his pay is what?

I see no immediate prospect of our civilization remaking itself. On the contrary, until civilization is forced by hunger, in the struggle for existence, to insure its food supply, the care of individual and public health, the protection of property and even the aspirations to a higher life will simply intensify the struggle for existence. We must readjust our rewards; we must compensate the producers of necessities at least as richly as we reward equal ability in other lines.

But to do this implies a social revolution in comparison with which those of the recent and more remote pasts are trifling; in which human nature, always controlled more by sentiment than by reason, will have to overcome the habits of centuries; in which wars, epidemics, famines will have their terrible parts; and before man achieves it or understands it, will have taken enormous toll

in human life. For until we have secured our food supply, we shall continue to be in jeopardy.

On the Mojave Desert is a settlement of six hundred souls, watered by a slender pipe-line miles long, supplemented by wells which furnish water so alkaline that it can be used only for washing and which gives the skin a curious sliminess. All the food of the community comes over a single track railroad thirty miles long. The community can make no water, grow and capture no food, on the desert. Nor would the community be better off if it consisted of one person instead of six hundred, including women and children, for the Mojave will not feed even a "desert rat." New York City has enough milk for a day and a half, other food for three days. Other communities are no better off, and if we all became farmers when our supplies fail it would do no good, for it takes time for food to be produced. Food is seasonal; it must be grown in summer and stored against the winter, spring and summer, till the succeeding harvest refills the granaries, or it must be captured. Races dependent upon the chase, whether upon land or sea, are limited in numbers and live scattered over extended areas. But civilized man lives no less uncertainly, though less obviously in jeopardy, till war or pestilence or calamitous weather reveals his weakness. Perhaps you imagine I am indulging in diluted allusions to the doctrine of Malthus. Not so. What I have in mind goes much further than Malthus; is truly wild if you will. While I believe what I think Malthus said about the relation of subsistence and population, I am saying that to insure any population beyond the sparsest and most active in the chase there must be due reward for the production of subsistence. The hunger of others will not cause you and me or any one else to take the bread from the mouths of our wives and children or to rob them of their seed corn for the next year's harvest. We saw this very recently in Russia. The farmer will continue to support the town only if he is paid for it, not if he is forced to the wall in the struggle for existence. His work, the most necessary and hence the most important, deserves no less reward than that of others. If he had learned the arts of combination we should know ourselves to be at his mercy. He seems to be at our mercy, for we force him to sell, and to undersell his neighbor. The result is the diminishing farm population. If this go too far, we shall all be hungry.

But if, instead of basing our civilization on an insecure food supply and pleasing ourselves with luxuries, we insure the production of food by proper compensation for the producer, we can be sure of the future. Then man, who has overcome the insufficient buoyancy of the air, the insufficient aeration of the sea, and the limitations of time and space, may look forward to a truly glorious development as the safest as well as the highest land animal.

# QUANTITATIVE DIETS VERSUS GUESSWORK IN THE TREATMENT OF OBESITY AND DIABETES

By Dr. H. GRAY and JEAN M. STEWART

FROM THE DIET LABORATORY OF THE MEDICAL DEPARTMENT OF THE STANFORD UNIVERSITY HOSPITAL

"The true remedy for diabetes is found not in the pharmacy but in the kitchen."—*Cantani.*

DIET to-day is a matter over which a surprisingly large group of people exhibit serious concern. In some instances it is laughable; in many tragic. In all it is a nuisance to the central figure, the family and only too often the circle of friends. Commonly dieting is conspicuous for its faddishness and remissions as soon as a few pounds have been lost: misguided and wasted effort which place that diet in the category of patent medicines. On the other hand, education in measured diets has become the cornerstone in the treatment of an increasing number of disorders of the chemistry of the body, such as obesity, diabetes, nephritis and epilepsy. This is due to the rapid expansion of knowledge about the basic *values* of the familiar *articles* of food. In this teaching and demonstration of foods an ever-growing rôle is being played by the dietitian.

### QUALITATIVE DIETS

By omitting certain articles of food, such as coffee when nervous, tobacco when short of breath, sugar and bread when diabetic, many patients obtain relief so substantial that further details are unnecessary; they are fortunate. Yes, fortunate, for after all there are few of us who escape some restrictions on our liberties!

### QUANTITATIVE ESTIMATED DIETS

The distinction between qualitative and quantitative diets has not been made at all clear to patients, and is of the first importance to all those who fail to improve on qualitative régimes within a reasonable length of time, say two to four weeks at the outside. The cause of failure as a rule is that while the patient is restricting certain articles of food she unconsciously increases others. To overcome this tendency she must be taught the underlying principles of the quantitative diet, namely, that any article of food may be eaten if in small enough amount, whereas no food should be eaten in unlimited quantities; that food must be thought of in terms of calories, carbohydrate, protein and fat, and that the quantitative estimation of these values is imperative. This quantitation may be begun in simple household terms of ounces and tablespoonfuls, one ounce being equal to one heaping or two level tablespoonfuls.

The teaching of these principles is started in most good clinics by requesting the patient to write down everything she eats for the next three meals, with a statement of the amounts as nearly as she can judge in tablespoonfuls or ounces, and to return with the list.

This is the sort of list she is apt to bring in:

Breakfast.

½ grapefruit, cereal 4 tablespoonfuls, toast 2 pieces, butter, coffee, cream.

Lunch.

1 chop, baked potato 3 heaping tablespoonfuls, carrots 3 heaping tablespoonfuls, sliced peaches and cream, graham bread 1 slice, butter, tea.

Dinner.

Slice roast beef medium sized, mashed potato 3 heaping tablespoonfuls, vegetable salad small, apple pie, bread 1 slice, butter, tea.

In any first lesson suggestions will be

necessary, and in the above case the patient's attention is drawn to the statement about the meat, pointing out that "one chop" may have consisted of one, two, four or more ounces, and that with articles like this the patient who has seen the chop can make a better guess than we can, so what would she hazard? Then we write it in. Similarly with the roast beef, with the salad, the butter and especially the pie. We point out the difficulty for us to do the estimating of the actual amount. On reaching the foot of the list we return it as a model, and ask her to repeat the process for two days and to return.

At this second visit she brings the two days' lists, and we calculate the food values rapidly for our own guidance. If the totals differ too widely we surmise in spite of the labor that went into them (and it is considerable for the patient on these first attempts), that the lists do not tell the patient's habits. More lists are asked for until a fair degree of uniformity becomes apparent.

A sample of a satisfactory calculation after the third visit may now be shown in Table I, with the explanation that just as tablespoonfuls were converted into ounces, so ounces are now converted into grams, because computations are easier in the metric system. Each ounce is considered equal to 30 grams, which is not exact but is near enough for the purpose of practice; thus three ounces of meat will be seen here as 90 grams, ten ounces of 5 per cent. vegetable as 300 grams, and so on. To compute the diet it is necessary to know the amount of the carbohydrate, protein and fat in each article of food; these values are to be found in the monograph by Atwater and Bryant, "The Chemical Composition of American Food Materials," Bulletin 28, Revised Edition, which was first issued in 1906; it can be purchased by sending ten cents in coin to the Superintendent of Documents, Washington, D. C. We have here used the simplified values given by Joslin in his peerless "Diabetic Manual," published by Lea and Febiger, Philadelphia, edition 4, 1929.

Now we have a more definite basis to build on, both as regards the articles of food this patient likes and the amounts of them which she is accustomed to eat. Recommendations are made appropriate to her condition, to increase such and

TABLE I

AVERAGE NORMAL DIET FOR A PERSON WEIGHING 61 KILOGRAMS (134 POUNDS). THE ESSENTIALS ARE THE AMOUNTS OF CARBOHYDRATE, PROTEIN, FAT AND CALORIES WHICH MAY BE DERIVED FROM AN ENDLESS VARIETY OF ARTICLES OF FOOD

| Article of food | Breakfast | Lunch | Supper | Total for the day | Carbohydrate | Protein | Fat |
|---|---|---|---|---|---|---|---|
| Meat cooked | | 90 | | 90 | | 24 | 15 |
| Egg | | 1 | | 1 | | 6 | 6 |
| 5 per cent. vegetables | | 300 | 300 | 600 | 20 | 10 | |
| Oatmeal (dry weight) | 30 | | | 30 | 20 | 5 | 2 |
| Bread | 30 | 15 | 30 | 75 | 45 | 8 | |
| Butter | 10 | 10 | 10 | 30 | | | 25 |
| Milk | 240 | | | 240 | 12 | 8 | 8 |
| Grapefruit | 100 | | | 100 | 5 | | |
| Orange | | 150 | 100 | 250 | 25 | | |
| Olive oil | | | 20 | 20 | | | 20 |
| | | Total grams | | | 127 | 61 | 76 |
| | | | | | ×4 | 4 | 9 |
| | | Total calories | | | 508 | 244 | 684 = 1427 |

such, to decrease such and such, in about this and that quantities; and after three days to bring her lists again. If this treatment shows results, again we call the patient lucky. If not, we must help her over the next necessary hurdle, namely, use of a food scales.

### Quantitative-weighed Diets

At this fence many patients shy; they will try any odd diet they hear of, particularly if it has a catchy or imposing name, or if it consists of only two articles or is otherwise so simple that it is easy to learn from, and to tell to, their friends. They do not realize or are reluctant to admit that such diets are one-sided and therefore can not be expected to be adequate for the needs of the body for more than a very short period; they resent being reminded that successful dietary treatment seldom can be achieved by a month's enthusiasm followed by a return to previous habits, but that success depends on developing new habits suitable to their personal needs.

When, however, they are persuaded to give a fair trial to weighing what they eat on a Chatillon or Hanson movable dial food-scales, or even a postal scales, and calculating the values until they have learned the real instead of the apparent weights of the various articles, they will as a rule be astounded to learn these straightforward facts:

1. That weighing is not so much work as they anticipate.

2. That after a week or two of such weighing, supplemented occasionally later by a day or two of repetition, they generally will be able to return to estimation by the eye.

3. That the same volumes of various articles of food differ greatly in weight.

4. That the same weights of various articles differ even more surprisingly in values of C, P, F.

5. That after the practice with figures in weighing, calculation of the values becomes easier.

6. That after having learned some calculations, they will be able to make substitutions in the diet ordered in such a way as to keep the values satisfactory to the physician and at the same time to keep the menu palatable to themselves.

The requirements of all diets have certain points in common: (1) Sufficient calories, (2) adequate protein, (3) carbohydrate and (4) fat in reasonable proportions, (5) vitamins A, B, C, D, E and G, (6) minerals and (7) bulk.

### Obesity

Excess fat is not only closely associated with the onset of diabetes in at least three quarters of the cases, but in other respects is a menace to long life. Overweights in general have a mortality more than twice the normal, but extreme overweights have a mortality about thirteen times the rate for underweights, as recently demonstrated by Dublin. The most favorable weight is that for one's height at the age of thirty years, as shown by the Association of Life Insurance Directors and Actuarial Society in 1912, from whose table is drawn the abridged form shown in Table II.

In order to reduce weight the principle concerned is the reduction of the total number of calories. The bulk of the articles of food, it must be remembered, does not tell the fuel value; to know this we must figure out the calories. At the outset, therefore, we list the articles eaten and make the computations described above under normal diets. When we have ascertained the patient's dietary habits, we then: (1) reduce the number of calories, and (2) plan that the patient shall take the amount of protein necessary for health. As to the carbohydrate and fat distribution there are many theories. These can not be detailed here; it is enough to state that they are quite secondary. For individual patients various distributions may be suitable because of special circumstances in the judgment of the physician or

TABLE II

AVERAGE WEIGHT IN POUNDS WITH CLOTHES

Men

Feet and inches with shoes

| Age | 5–0 | 5–1 | 5–2 | 5–3 | 5–4 | 5–5 | 5–6 | 5–7 | 5–8 | 5–9 | 5–10 | 5–11 | 6–0 | 6–1 | 6–2 | 6–3 | 6–4 | 6–5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 109 | 111 | 114 | 117 | 120 | 124 | 128 | 132 | 136 | 140 | 144 | 149 | 154 | 159 | 164 | 169 | 174 | 179 |
| 18 | 113 | 115 | 118 | 121 | 124 | 128 | 132 | 136 | 140 | 144 | 148 | 153 | 158 | 163 | 168 | 173 | 178 | 183 |
| 20 | 117 | 119 | 122 | 125 | 128 | 132 | 136 | 140 | 144 | 148 | 152 | 156 | 161 | 166 | 171 | 176 | 181 | 186 |
| 22 | 119 | 121 | 124 | 127 | 131 | 135 | 139 | 142 | 146 | 150 | 154 | 158 | 163 | 168 | 173 | 178 | 183 | 188 |
| 24 | 121 | 123 | 126 | 129 | 133 | 137 | 141 | 144 | 148 | 152 | 156 | 160 | 165 | 171 | 177 | 182 | 187 | 192 |
| 26 | 123 | 125 | 127 | 130 | 134 | 138 | 142 | 146 | 150 | 154 | 158 | 163 | 168 | 174 | 180 | 186 | 191 | 196 |
| 28 | 125 | 127 | 129 | 132 | 135 | 139 | 143 | 147 | 151 | 155 | 159 | 164 | 170 | 176 | 182 | 188 | 193 | 198 |
| 30 | 126 | 128 | 130 | 133 | 136 | 140 | 144 | 148 | 152 | 156 | 161 | 166 | 172 | 178 | 184 | 190 | 196 | 201 |
| 32 | 127 | 129 | 131 | 134 | 137 | 141 | 145 | 149 | 154 | 158 | 163 | 168 | 174 | 180 | 186 | 192 | 198 | 203 |
| 34 | 128 | 130 | 132 | 135 | 138 | 142 | 146 | 150 | 155 | 160 | 165 | 170 | 176 | 182 | 188 | 194 | 200 | 206 |
| 36 | 129 | 131 | 133 | 136 | 139 | 143 | 147 | 151 | 156 | 161 | 166 | 171 | 177 | 183 | 190 | 196 | 202 | 208 |
| 38 | 130 | 132 | 134 | 137 | 140 | 144 | 148 | 152 | 157 | 162 | 167 | 173 | 179 | 185 | 192 | 198 | 204 | 210 |
| 40 | 131 | 133 | 135 | 138 | 141 | 145 | 149 | 153 | 158 | 163 | 168 | 174 | 180 | 186 | 193 | 200 | 206 | 212 |
| 42 | 132 | 134 | 136 | 139 | 142 | 146 | 150 | 154 | 159 | 164 | 169 | 175 | 181 | 187 | 194 | 201 | 208 | 214 |
| 44 | 133 | 135 | 137 | 140 | 143 | 147 | 151 | 155 | 160 | 165 | 170 | 176 | 182 | 188 | 195 | 202 | 209 | 215 |
| 46 | 134 | 136 | 138 | 141 | 144 | 148 | 152 | 156 | 161 | 166 | 171 | 177 | 183 | 189 | 196 | 203 | 210 | 216 |
| 48 | 134 | 136 | 138 | 141 | 144 | 148 | 152 | 156 | 161 | 166 | 171 | 177 | 183 | 190 | 197 | 204 | 211 | 217 |
| 50 | 134 | 136 | 138 | 141 | 144 | 148 | 152 | 156 | 161 | 166 | 171 | 177 | 183 | 190 | 197 | 204 | 211 | 217 |
| 52 | 135 | 137 | 139 | 142 | 145 | 149 | 153 | 157 | 162 | 167 | 172 | 178 | 184 | 191 | 198 | 205 | 212 | 218 |
| 54 | 135 | 137 | 139 | 142 | 145 | 149 | 153 | 158 | 163 | 168 | 173 | 178 | 184 | 191 | 198 | 205 | 212 | 219 |

Women

| Age | 4–8 | 4–9 | 4–10 | 4–11 | 5–0 | 5–1 | 5–2 | 5–3 | 5–4 | 5–5 | 5–6 | 5–7 | 5–8 | 5–9 | 5–10 | 5–11 | 6–0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 102 | 104 | 106 | 108 | 109 | 111 | 114 | 117 | 120 | 124 | 128 | 132 | 136 | 139 | 143 | 148 | 153 |
| 18 | 104 | 106 | 108 | 110 | 112 | 114 | 117 | 120 | 123 | 126 | 130 | 134 | 138 | 141 | 145 | 150 | 155 |
| 20 | 106 | 108 | 110 | 112 | 114 | 116 | 119 | 122 | 125 | 128 | 132 | 136 | 140 | 143 | 147 | 151 | 156 |
| 22 | 107 | 109 | 111 | 113 | 115 | 117 | 120 | 123 | 126 | 129 | 133 | 137 | 141 | 145 | 149 | 153 | 157 |
| 24 | 109 | 111 | 113 | 115 | 117 | 119 | 121 | 124 | 127 | 130 | 134 | 138 | 142 | 146 | 150 | 154 | 158 |
| 26 | 110 | 112 | 114 | 116 | 118 | 120 | 122 | 125 | 128 | 131 | 135 | 139 | 143 | 147 | 151 | 155 | 159 |
| 28 | 111 | 113 | 115 | 117 | 119 | 121 | 123 | 126 | 130 | 133 | 137 | 141 | 145 | 149 | 153 | 156 | 160 |
| 30 | 112 | 114 | 116 | 118 | 120 | 122 | 124 | 127 | 131 | 134 | 138 | 142 | 146 | 150 | 154 | 157 | 161 |
| 32 | 113 | 115 | 117 | 119 | 121 | 123 | 125 | 128 | 132 | 136 | 140 | 144 | 148 | 152 | 155 | 158 | 162 |
| 34 | 115 | 117 | 119 | 121 | 123 | 125 | 127 | 130 | 134 | 138 | 142 | 146 | 150 | 154 | 157 | 160 | 163 |
| 36 | 116 | 118 | 120 | 122 | 124 | 126 | 128 | 131 | 135 | 139 | 143 | 147 | 151 | 155 | 158 | 161 | 164 |
| 38 | 117 | 119 | 121 | 123 | 125 | 127 | 130 | 133 | 137 | 141 | 145 | 149 | 153 | 157 | 160 | 163 | 166 |
| 40 | 119 | 121 | 123 | 125 | 127 | 129 | 132 | 135 | 138 | 142 | 146 | 150 | 154 | 158 | 161 | 164 | 167 |
| 42 | 120 | 122 | 124 | 126 | 128 | 130 | 133 | 136 | 139 | 143 | 147 | 151 | 155 | 159 | 162 | 166 | 169 |
| 44 | 122 | 124 | 126 | 128 | 130 | 132 | 135 | 138 | 141 | 145 | 149 | 153 | 157 | 161 | 164 | 168 | 171 |
| 46 | 123 | 125 | 127 | 129 | 131 | 133 | 136 | 139 | 142 | 146 | 150 | 154 | 158 | 162 | 165 | 169 | 172 |
| 48 | 124 | 126 | 128 | 130 | 132 | 134 | 137 | 140 | 143 | 147 | 152 | 156 | 160 | 164 | 167 | 171 | 174 |
| 50 | 125 | 127 | 129 | 131 | 133 | 135 | 138 | 141 | 144 | 148 | 152 | 156 | 161 | 165 | 169 | 173 | 176 |
| 52 | 125 | 127 | 129 | 131 | 133 | 135 | 138 | 141 | 144 | 148 | 152 | 157 | 162 | 166 | 170 | 174 | 177 |
| 54 | 125 | 127 | 129 | 131 | 133 | 135 | 138 | 141 | 144 | 148 | 153 | 158 | 163 | 167 | 171 | 174 | 177 |

because of special tastes on the part of the patient. No amount of palaver can evade the fundamental fact that the calories, not necessarily the bulk, must be cut down below existing habits, and that new habits must be formed.

## DIABETES

*Diabetic diets.*—In 1928 Joslin, the leading exponent of diabetes in this country wrote:

It is only within half a generation that diets have been accurately controlled for months and

years and the quantities of carbohydrate, protein and fat recorded, and only within the last twelve years that the total quantity of food has been at all closely limited. In consequence it is only to-day that we are in a position to compare the effects of various diets, only to-day that we can begin to discuss how, for instance, it is best to distribute a given intake between the three foodstuffs.

Almost every physician treating diabetes more carefully than by simple omission of bread has used a different method. Some of these exhibit material differences; most are variations of existing plans of greater or less antiquity. All are fairly complex, with the result that patients, and even their medical advisers who see only occasional diabetic patients, are needlessly confused. Furthermore, the vast number of variations render comparisons of the results extremely uncertain. An immediate need would therefore seem to be the definition of a few types of diet, into which current methods may be grouped somewhat categorically. This grouping would simplify understanding of the principles involved, and make possible analysis of the consequences of emphasis on one or other of these principles. Such an attempt at definition will accordingly be presented, but first we must explain a few of the principal peculiarities of the chemical metabolism in diabetes.

When carbohydrate has been digested in the intestine and absorbed through the intestinal wall and into the blood stream it is in the simplest form of sugar, called glucose, grape sugar or dextrose. To start this burning we must have a match. In the body this match is a secretion from certain cells in the pancreas which are called the islands of Langerhans because they were discovered by that investigator and, under the microscope, looked like distinct islands of one kind of cell in the midst of the already known cells which secrete the various other digestive juices; this secretion is called insulin. If the pancreas is injured, by infection or other causes, enough to cause depletion of the insulin, the result is diabetes. It is estimated that one unit of insulin burns about two grams of glucose. If reduction of the carbohydrate in the diet does not make the urine sugar-free, then insulin made from animals must be taken by injection. This is much less trouble and annoyance than would be expected.

Just as a certain amount of insulin is necessary to burn a certain amount of glucose, so a certain amount of glucose is necessary to burn the fat completely, so that no waste fat will be left over to form poisonous fatty acids in the blood and cause coma. It is estimated that one gram of glucose burns about 1.5 grams of fatty acid.

In diabetes it is generally necessary to reduce the total calories just as in obesity, but it is also important to rearrange the distribution of carbohydrate and fat. When the carbohydrate in the diet is cut down, the shortage may be made up by the body changing into carbohydrate 58 per cent. of the protein and 10 per cent. of the fat digested. Thus in calculating the total glucose of the diet which must be balanced by insulin, either that made by the patient in his own body or taken by injection, we must include these available supplies, supposing the diet consists of carbohydrate 84 grams, protein 61 grams, fat 94 grams:

| | |
|---|---|
| Carbohydrate | 84 grams |
| 58 per cent. of protein, *i.e.*, 58 per cent. of 61 = | 35.4 grams |
| 10 per cent. of fat, *i.e.*, 10 per cent. of 94 = | 9.4 grams |
| Total available glucose | 128.8 grams |

The energy requirements of the body are supplied entirely by the burning of the food we eat. This food is divided chiefly into three kinds: (1) Carbohydrate, which is mostly of vegetable origin: sugars, starches, grains, cereals, fruits; (2) protein, which is mostly of animal origin: meat, fish, eggs, milk, cheese; (3) fat, which comes partly

from vegetable sources: olive oil and cottonseed oil, and partly from animal sources: butter and lard.

The amount of this energy is measured in calories, just as butter is measured in pounds. A calory is the quantity of heat necessary to increase the temperature of 1 liter (1.06 quarts) of water 1 degree Centigrade. Food when burned in the body gives off heat in the following amounts:

| | |
|---|---|
| 1 gram of carbohydrate yields | 4 calories |
| 1 gram of protein yields | 4 calories |
| 1 gram of fat yields | 9 calories |
| 1 gram of alcohol yields | 7 calories |

*Definitions of type diets in health and diabetes.*—Suppose we have in bed before us a patient weighing, after subtracting for clothing, 61 kilograms (134 pounds). Her protein should be about 1 gram per kilo, *i.e.*, 61 grams. Her calory need, since she is at rest, will be satisfied by about 23 calories per kilo body weight, *i.e.*, 23 x 61 or about 1,400 calories. Diets which are alike in these two respects may be called iso-caloric (equal calory) and iso-protein. Of such diets we now present four types which seem to us of distinct interest as illustrating the seesaw or inverse relationship between the distribution of carbohydrate and fat: when one goes down, the other goes up; when the carbohydrate is lowest the fat is highest, and *vice versa*. The figures are briefly shown in Table III and Fig. 1.

## Some Other Medical Aspects of Diabetes Mellitus

*Definition.*—Diabetes is a disease in which part of the food is not utilized and appears as sugar in the urine.

*Frequency of the disease.*—Among the hundred million inhabitants of the United States there are supposed to be about one million diabetics. Also among the annual number of deaths in this country those from diabetes make up about 1 per cent. Diabetes ranks about tenth among causes of death; among the commoner causes the best known are cancer, heart disease, kidney disease, pneumonia, tuberculosis and violence. In other countries the frequency of death as reported varies considerably, ranging from 0.1 per cent. in Japan to 3.6 per cent. in the Netherlands. How far these differences are due to racial characteristics and how far to accuracy of statistics is unknown.

TABLE III

Diets in Health and Diabetes

| Type of diet | C | P | F | Cal. | Ratio FA : G |
|---|---|---|---|---|---|
| Low carbohydrate diabetic | 41 | 61 | 112 | 1416 | 1.5 |
| Average diabetic | 84 | 61 | 94 | 1426 | 0.9 |
| Normal | 128 | 61 | 75 | 1423 | 0.5 |
| High carbohydrate diabetic | 139 | 61 | 70 | 1424 | 0.3 |

*Age at onset.*—Half of all diabetics show onset of the disease between 40 and 60 years of age. The youngest patient reported was $2\frac{1}{2}$ months old at onset. The relative frequency of onset in the successive decades of life is shown by Joslin's tabulation based on 5,086 patients seen by him.

| Age | 1–10 | 10–20 | 20–30 | 30–40 | 40–50 | 50–60 | 60–70 | 70–80 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Per cent. | 5 | 7 | 9 | 13 | 25 | 26 | 13 | 2 | 100 |

In the first ten years of life the affliction is seen to be relatively rare, being about 5 per cent. of the total. This is fortunate because the disease is more severe in children than in adults. However, we no longer feel alarmed at the diagnosis in a child, because: (1) Insulin has made possible adequate food for growth and activity. (2) The child's preference for plain foods and the foods he knows makes good dietary habits and diet measurement easier than for the

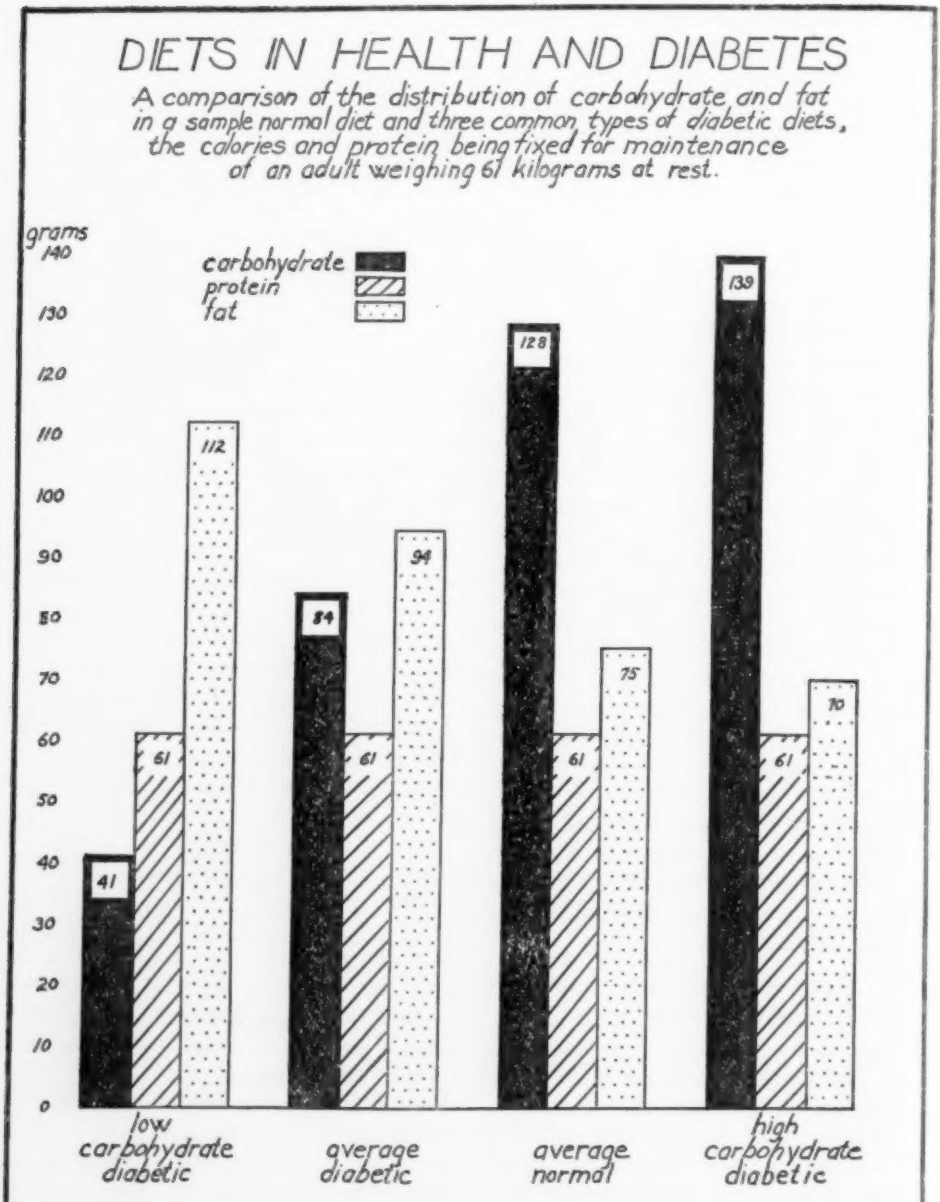

DIETS IN HEALTH AND DIABETES
A comparison of the distribution of carbohydrate and fat in a sample normal diet and three common types of diabetic diets, the calories and protein being fixed for maintenance of an adult weighing 61 kilograms at rest.
grams
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
carbohydrate
protein
fat
41
61
112
84
61
94
128
61
75
139
61
70
low carbohydrate diabetic
average diabetic
average normal
high carbohydrate diabetic

FIG. 1

adult who so often expects great variety. (3) Children are so much more adaptable than adults.

A diabetic child usually looks as if in perfect health. It is a remarkable fact that diabetic children are often unusually intelligent, standing high in their classes.

*Diagnosis.*—Early recognition is ten times as common to-day as it was 50 years ago. This is due to routine urinary testing, whether as part of examination for life insurance or health supervision. Such routine tests can reveal the disease months before the advent of symptoms such as thirst, getting up at night, loss of weight, dry skin or itching. Early diagnosis is unquestionably the best hope of recovery in this as in other diseases.

*Treatment.*—The determination of the sugar in the blood is useful, but the main gauge of successful treatment in ordinary practice is the freedom of the urine from sugar. This fact must be insisted upon, over and over again. As long as the urine is not sugar-free the patient is liable to complications varying from pimples, boils, itching, muscle aches, arteriosclerosis; to ulcers, gangrene, cataract, coma and even death. Small amounts of sugar are far too often neglected because the patient feels well.

The patient's help is indispensable for successful treatment, and this means: (1) Regular visits to the physician, at least once in 6 months; special visits at any time that sugar appears in the urine and can not be eliminated by the patient within three days, and immediate notification of the doctor in case of fever, acute digestive or other upsets. (2) Bringing on each visit to the physician a list of the articles of food eaten during the preceding 24 hours, not forgetting to write down the approximate amounts. (3) Regular tests for sugar with Benedict's solution, often enough to keep sugar-free; this varies according to the severity of the disease from twice a day to twice a month. (4) Getting weighed regularly, generally once a week. (5) Weighing articles of food whenever guessing proves insufficient to produce sugar freedom. (6) Taking insulin if this weighing also proves insufficient, and also in case of certain complications.

*Insulin.*—At this point it is well to remark that insulin offers no sudden cure like a surgical operation, as some fancy and as we all wish were the case; hence when insulin treatment is discontinued the diet must often be decreased somewhat, and on this the physician should be consulted. Furthermore, there is doubtful benefit and often real danger in taking insulin unless the patient is both willing and able to estimate the food accurately, otherwise wastage is sure and shock-reactions to be feared. Four fifths of diabetics need no insulin except temporarily in acute infections and in surgical emergencies, while the remaining one fifth should not expect to receive much benefit from insulin unless they measure their food intake. Actual calculation of the C–P–F values can be escaped by some patients, but all are better off when they have learned how, even though they may calculate only occasionally, for thus they can make substitutions in diet while traveling or eating elsewhere away from home.

*Summary.*—Obesity and diabetes alike offer the optimistic aspect that improvement can be promised with a noteworthy degree of confidence to the patient who cares enough about health to "play ball."

"There is no drug as powerful as hope."—*Axel Munthe.*

# THE DECLINE IN BIRTH-RATE OF THE FOREIGN BORN

By Dr. JOSEPH J. SPENGLER

UNIVERSITY OF ARIZONA

JUST eighty years ago Dr. Jesse Chickering observed that the foreign-born women of Boston were bearing far more children than the native women. "The whole increase from the excess of births over deaths for these two years [1849–1850]" he observed, "has been among the foreign population." Not many years later it became generally feared that immigrant women, through their greater fecundity, would inundate New England with foreign stock. The natives who, according to John Adams, were "purer English blood—than any other" seemed threatened with displacement at the hands of the Irish, the Germans and others.

In the present paper I shall sketch briefly the growth of this fear of the effects of a relatively greater foreign fecundity. I shall then present the available data and show whether or not the native American will eventually succumb to the foreign stock as a result of the reproduction struggle still going on.

## I

The first data we have concerning the comparative birth-rates of native and foreign-born women were obtained in the census of Boston in 1845. Prior to the forties there was little immigration into the United States. Most of those who came were English and hence hardly distinguishable from the natives. In the forties, however, many Irish fled from famine-stricken Erin and many Germans hurried from revolution-torn Germany. The immigrant population, therefore, became distinguishable from the native population and was so registered in the records of the day, such as the census, the birth registration reports, etc. One notes accordingly that in Boston in the year 1845 there were 80 births to each 1,000 foreigners aged more than twenty years. The corresponding native rate was 41, or but half the foreign rate. In the Broad Street section of Boston 212 children were born in 1845 to 2,131 inhabitants, mostly foreign born. That is, one child was born for each five women. Needless to say the burial records testify to an exceptionally high infant mortality rate among the foreign born.

Fear of superior foreign fecundity was not expressed, however, until the births to foreign parents began generally to be distinguished from births to native parents. This distinction was made in Massachusetts in 1848, and somewhat later in the other New England states, in Michigan and in Indiana. Dr. Chickering's expression of fear was repeated in the late eighteen sixties by Dr. Nathan Allen, of Lowell, Massachusetts, a prolific writer on the alleged decline of the native stock. Allen charged that the native stock was dying out through failure of native women to bear children while at the same time the newly arrived foreigners were multiplying rapidly. New England, therefore, seemed doomed soon to be overrun by immigrant stock.

In 1869 the compiler of the Massachusetts registration report sanctioned Allen's statement by remarking that the English stock, meaning primarily the natives, is "likely to be at no very distant day outnumbered by the Irish, the Germans and the French Canadians."

Because of the increasing interest in the problem the census enumerators in the state censuses of New York, Massachusetts, Rhode Island and Michigan, and in the federal censuses of 1890, 1900 and 1910, were instructed to inquire of women the number of children they had borne. The material obtained in Massachusetts, Rhode Island and Michigan showed conclusively that foreign-born women bore more children than did the native women. The Rhode Island data indicated further that while Jewish women were more fecund than Catholic women, and Catholic women more fecund than Protestant women, the foreign-born women of each creed averaged more children than did the natives. As is sometimes characteristic of the federal census, only a small portion of the material secured was published. It was made evident, however, that foreign-born married women in Rhode Island and parts of Ohio and Minnesota bore more children than did the native women, and that native-born women of foreign parentage bore fewer children than foreign-born women but more children than natives of native grandparentage. That is, the birth-rate of the foreign stock gradually becomes Americanized in the course of a generation.

Careful studies by Dr. R. R. Kuczynski and Allyn Young confirmed some of the conclusions stated above and indicated also that foreign-born women bore more children at all ages than did native women of corresponding ages.

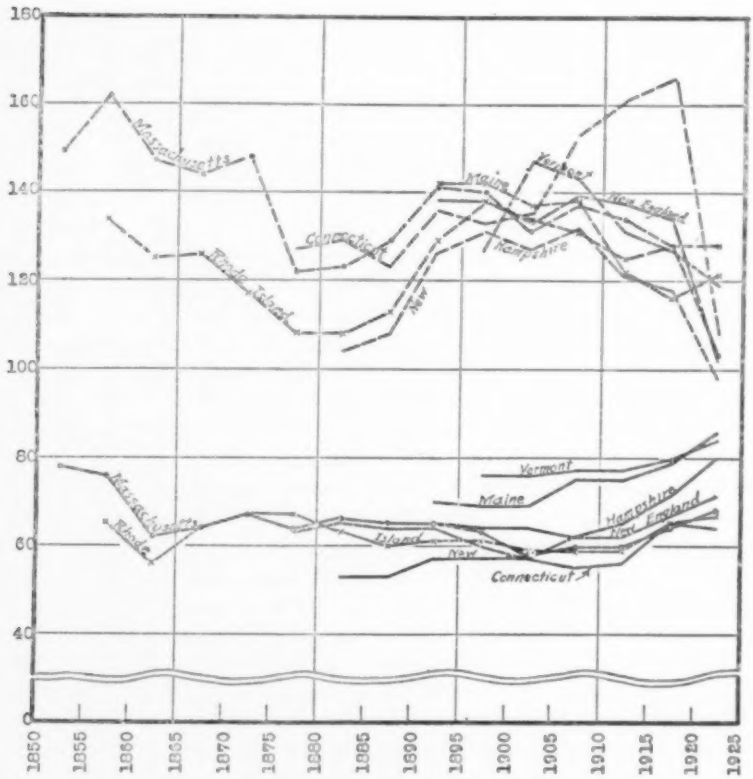
It was but a step from noting that foreign-born women bore more children than natives to arguing that the influx of the foreign-born immigrants was the cause of the decline in the American birth-rate. General Francis Walker, a prominent economist and a superintendent of the federal census, developed this argument in an article in *Forum*, 1891, entitled "Immigration and Degradation." Walker contended that the coming of the immigrants shocked American sentimentalities and initiated an "industrial competition" from which "the American shrank. If the foreigners had not come the native element would long have filled the places the foreigners usurped." In other words, Walker was contending that, had there been no immigration, the American population would have been just as numerous as it is to-day. In place of the 53 millions alleged to be of immigrant stock there would have been 53 more millions descended from native American stock. That is, had there been no immigration into the United States the three million whites of 1790 would have increased to 95 millions by 1920, a geometrical rate of increase such as Malthus alleged was true of eighteenth century America.

Although such leading authorities as Commons, Bushee and Fairchild support Walker's theory in large part, E. A. Goldenweiser has refuted it by showing that the real causes of the decline in the American birth-rate are but remotely related to immigration.

Thus far I have shown that it has long been contended and frequently substantiated that foreign-born women were bearing more children than native women. I shall now examine briefly the causes of this difference and then demonstrate that the foreign-born women will soon be bearing no more children than the natives.

## II

In the accompanying chart are traced the trends in the average number of children born to each 1,000 native and to each 1,000 foreign-born women of child-bearing age in the New England states. The rates delineated in this chart are taken from a monograph by the writer entitled "The Comparative Fecundity of the Native and of the




NATIVE AND FOREIGN FERTILITY IN NEW ENGLAND

Foreign-Born Women of New England," published this year as one of the Brookings Institution Population Studies under the supervision of Dr. Robert R. Kuczynski.

The solid lines depict the fertility of the native women; the broken lines depict the fertility of the foreign-born women. If we examine the lines depicting the trend in native fertility we find that in the two states for which we have evidence, Massachusetts and Rhode Island, the Civil War occasions a sharp decline in fertility. Thereafter in each of these states native fertility remained practically unchanged. In the other four New England states and in the entire New England area native fertility has increased in the present century. This conclusion is contrary to the customary assertion that the native birth-rate is declining in New England.

The broken lines representing foreign fertility depict a remarkable decline in the fertility of foreign-born women. The most striking decline has taken place in Massachusetts. There we find foreign fertility only five eighths as great since 1920 as during the five years preceding the Civil War. In other states the decline, while not so great as in Massachusetts, has been striking. The foreign-born women living in New England during the five years after 1920 averaged only three fourths as many children as did the foreign-born women during the last decade of the nineteenth century. In short, foreign fertility has decreased 26 per cent. in 30 years.

The sharp decline in foreign fertility

coupled with the failure of native fertility to continue to decline means, as examination of the chart makes plain, that in the near future the native rates will be no lower than the foreign rates. In the chart this is indicated by the fact that the broken lines and solid lines are converging toward each other.

This convergence within the last few decades may be illustrated in another fashion. At one time foreign fertility was more than twice as high as native fertility in every state but Vermont. Yet, since 1920, for New England as a whole, foreign-born women have been averaging only three sevenths more children than native women. The data for New York, Indiana and Michigan indicate a similar convergence. We may conclude, therefore, that in nine states the differences between native and foreign fertility are rapidly disappearing.

## III

Thus far we have demonstrated that, contrary to general opinion, native fertility has not only not decreased in New England but has actually increased. We have shown further that foreign fertility has steadily declined and will soon be as low as that of the natives. In the present section it will be indicated that birth control is the sole explanation of the decline in foreign fertility.

The main reason that the fertility of the foreign-born exceeds that of native-born women is the fact that a much larger percentage of the foreign-born women of child-bearing age are living in the married state. More than 99 per cent. of children are born to women aged from 15 to 49. The number of children a population can bear, therefore, depends upon the proportion in that population of women aged 15 to 49, and in turn upon the proportion of women aged 15 to 49 who are married. During the last half century 47 of every 100 native women, aged 15 to 49, have been married. In 1890 of every 100 foreign women of this age 54 were married. By 1920 the proportion had increased to 72.

On the grounds of marriage alone, in 1890 foreign fertility should have been 15 per cent. higher than native fertility; by 1920 foreign fertility should have exceeded native fertility by about 50 per cent. Yet whereas in 1890 foreign fertility was twice as great as native fertility, by 1921–1925 it was only 44 per cent. greater than native fertility. In short, whereas we should have expected foreign fertility in 1920 to be 33 per cent. higher than foreign fertility in 1890, we find instead a sharp decrease of one fourth.

The only explanation of this sharp decline in foreign fertility lies in an increased resort to birth control on the part of foreign-born women. Advocates of birth control can, as a reading of the *Birth Control Review* will indicate, offer many individual cases of foreign-born women who unfortunately know nothing of the practice of birth control. Nevertheless the figures I present clearly prove that an increasingly larger proportion of foreign-born women are voluntarily restricting the number of children. Possibly, too, a great many are resorting to abortion. It has, in fact, frequently been asserted that between one half million and two millions of abortions are performed annually in the United States. Proof of this alleged high frequency of abortion is, in the nature of the case, not possible.

That foreign-born women living in New England, New York, Indiana and Michigan are practicing birth control or resorting to abortion in nearly the same degree as native women is readily demonstrable. Since we know that American married women are restricting the number of births it follows that foreign-born married women must be doing likewise if it can be shown that foreign-born married women are bearing, on the aver-

age, few more children than native married women. In the years 1919 and 1920 foreign-born married women in New England bore on an average only 26 per cent. more children than did native married women. By 1922 this margin had fallen to 18 per cent. in Connecticut and to still less in Vermont, New Hampshire and Rhode Island. In New York in 1922 foreign-born married women bore on an average only 14 per cent. more children than did native married women; in Indiana, 8 per cent. more; in Michigan the rates for native and foreign-born married women were nearly identical. In other states the same general trend is noted in 1922, the last year for which data are available. In that year in the United States Registration Area (27 states and the District of Columbia) the number of births per 1,000 native married women, aged 15 to 44 years, was 155; per 1,000 foreign-born married women of corresponding age, 159.

IV

Our argument as presented in the earlier parts of this article may be briefly summarized. Seventy-five years ago foreign-born women were bearing more than twice as many children per woman as were native women. However, foreign-born women gradually began to copy the practices used by their American sisters to restrict the number of children. Consequently foreign fertility steadily declined. Native fertility, on the contrary, has either remained constant or has actually increased in New England and possibly in certain other states. As a result of this decline in foreign fertility coupled with the cessation of decline in native fertility to-day we find foreign fertility nearly as low as that of the natives. In fact, it probably will soon be as low. At present foreign fertility exceeds native fertility chiefly because more foreign-born women marry. Since we know that American married women restrict the birth-rate and since we find that foreign-born married women average few more children than do native married women it follows that in a number of states foreign-born women practice birth control and resort to abortion as frequently as do native women.

From the data we have presented and analyzed we may draw several more philosophical conclusions. The situation we have traced in New England is analogous to the situation in Europe several decades ago and to the so-called eugenic situation to-day. For nearly three quarters of a century French nationalists, contrasting the low birth-rate in France with the high birth-rate in Germany, Italy and other parts of Europe, were aghast. Would France not be destroyed by the greater fecundity of foreign peoples? Levasseur in 1890 suggested that all European birth-rates would tend to equilibrium, to equality, in the course of time. Dr. R. R. Kuczynski, in his "The Balance of Births and Deaths," has proved that Levasseur was right. To-day European birth-rates are rapidly approaching equality.

Eugenists have frequently argued that Western civilization would be destroyed through the multiplication of the unfit at the expense of the fit. Yet to-day statistics of such countries as Sweden reveal that in some instances the abler classes are actually bearing more children than the less able classes.

Essentially, therefore, birth control is a great leveler. It has promoted equality in the birth-rates of the native and the foreign-born stocks of America. It has equalized the birth-rates of various European peoples. It has been adopted by the allegedly less able classes and has thus partially solved the eugenic problem on the negative side.

From the fact of the general adoption of birth control in Europe and by the

foreign-born immigrants in the United States it is apparent that the desire to restrict births is an essential aspect of what is called Western civilization. Arsène Dumont and Leroy-Beaulieu drew attention to this in the last decade of the nineteenth century. According to Leroy-Beaulieu, "Civilization, which is really the development of material ease, of education, of equality and of aspirations to rise and to succeed in life, has undoubtedly conduced to a diminution of the birth-rate." Civilization, as we understand it, means also that a child has become an economic and social liability rather than an asset; that in the new material scale of values the child has been replaced by the Ford; that to-day the pecuniary value of the things desired exceeds the pay envelop more than ever before; that the present view is not other-worldly, but this-worldly.

Oswald Spengler, in his "Decline of Western Civilisation," asserts that "when the ordinary thought of a highly cultivated people begins to regard 'having children' as a question of pro's and con's, the great turning point has come." The beginning of the end is at hand. As evidence he points to Hellas, to Rome, to India, to China. It has been statistically demonstrated that because of an insufficiency of births the populations of most of the European and English-speaking countries are dying out. May one therefore conclude that the American population will ultimately die out?

The data we have presented seem to yield a negative answer to the question raised in the preceding paragraph. For fifty years native fertility has been very low in New England, but for fifty years native fertility has not decreased. It would appear, therefore, that native fertility has reached as low a level in New England as will ever be experienced there. And from this one might generalize that when fertility in other parts of the United States has become as low as it has been in New England there will be no further decline. But as Corrado Gini and others have suggested, the American people may be experiencing a decline in their natural capacity to bear children, a decline that has merely been halted temporarily by the infiltration of foreign blood. If Gini is right the American along with the Teuton may be doomed to disappear. On the contrary, if the limit of the decline in fertility has been reached then America will shortly have achieved a stationary population, possibly the only means of escape from the Malthusian devil of overpopulation and the Spenglerian specter of race suicide.

# CURANDEROS IN OAXACA, MEXICO

By Dr. ELSIE CLEWS PARSONS

LIKE so many early Spanish customs or institutions, the institution of *curandero* or village curer is wide-spread in Mexico. Recently in the state of Oaxaca, more particularly among the Zapoteca-speaking towns, I have been making a study of these Spanish-Indian doctors and diviners who might be called shamans in an out-and-out Indian culture, or soothsayers and quacks in more sophisticated circles.

All *curanderos* are good Catholics, like most of the townspeople, maintaining their house altar and in their professional practice addressing the saints. There is no organization among the *curanderos* of a town—rather competition and a tendency to professional jealousy. They are men or women, *curanderos* or *curanderas*, and in their methods, whether of curing or divining, there appears to be but one distinction as far as sex is concerned, the *curandera* commonly functions as midwife. Some *curanderas* do not, just as some *parteras* or midwives are not considered *curanderas*. In other respects also the practice of one *curandero* varies somewhat from that of another. Isidora, of Mitla, is herb doctor and midwife as contrasted with Agustina Gonzalez who sucks for witchcraft and divines with corn. Urbano, of Mitla, is an herbalist, but he also "sucks." María García practices a method of divining with corn which she learned at Cuilápam, a Mixteca-speaking town. This is her single professional accomplishment. Margerita Hernández, of San Baltazar in the mountains, divines not with corn but with cards, and she "sucks." Josefa, of Zaachila, a midwife, also "sucks." José Martínez, of San Miguel, Alvarrados, another mountain town, divines with corn and cures with herbs, but does not "suck." "*Chupando es mentira*" (sucking is falsehood), opined the herbalist of Cuchitan, on the Isthmus.

Sucking out the object the witch has sent into the body is a very wide-spread Indian practice, and I believe the contemporary usage in Oaxaca is a survival from pre-Conquest times, even if the setting of the cure is Spanish. The witch-sent object, *chizo* (probably from *hechizera*, witchcraft) or *chaneca*, a term less commonly used, may be thorns, glass, stones, bones or anything noxious to the flesh. At Zaachila, cramps in my legs were diagnosed as caused by red ants in the abdomen. Among the Pueblo Indians of New Mexico, by the way, ants within the body is a very common diagnosis of skin eruptions.

At Zaachila I was not treated, but at Mitla I was sucked—for headache, caused not by *chizo*, but by *aïre*, that perplexing source of sickness which is sometimes referred to as if it were a spirit of the air[1] and at other times as if nothing more than a draft.

"Why do you think so much?" asked Agustina. "You think and then *el aïre se pega*, the air catches you, you hear a drum in your head. *Sola?*"

"Si."

"*Su marido?*"

"*Muerto.*"

"*Es razón por piensar.*"

As for "the air," she would suck to get it out.

"But it hurts. You may not be able to stand the pain."

"Draw blood?"

"No."

[1] In Morelos and Puebla there is no mistaking the supernatural character of *los aïres*. See Robert Redfield, "Tepoztlan," Chicago, 1930; E. C. Parsons, "Folklore from Pueblo," *Journal American Folk Lore*, in proof.

Reassured, for Agustina's remaining teeth were black, I gave her the five centavos she requested in order to send the little girl for a half bottle of *aguardiente*.

We talk. Agustina was not born in Mitla, but in Copainala, Tabasco. Her father was *curandero,* her art was *una herencia*—the only instance I encountered of coming to the profession through inheritance—and her father's brother was a priest. From this priestly uncle she learned the prayers she used professionally. San Antonio is her special charge, and his picture is, of course, on her altar, together with bits of candle, two vases of freshly cut stock and some egg-shells. Underneath is the copal censer which in religious observance is used almost as much as candles by the Zapoteca-speaking household.

Now Agustina takes a drink, spitting after it, and she urges one on me, to fortify me against the pain. Over the back of my neck she passes her fingers, firmly, then she anoints with oil, and then sucks, in three places, right side, left side and middle. The suction is strong, at the sides of the neck producing some pain. She spits each time into the inner leaves of a corn husk, which she finally burns, and each time before sucking she prays in a low voice, "Dios, Espíritu Santo, San Antonio, make the sickness come out!"

Agustina, of Mitla, and Josefa, of Zaachila, used almost the same method of diagnosis. You held out your two arms, bared; over them from her mouth Josefa spurted some *aguardiente,* a preliminary omitted by Agustina. Your pulse was tested by a thumb on each wrist, then on the arm below the elbow. Agustina vibrated her thumbs as she tested. Again the same form of diagnosis by José Hernández, of Matatlan, when I opined that Eligio, my companion from Mitla, was bewitched, having cramps in his arms. José was not to be fooled by that pair of strong, supple arms. "You only think you have *chizo,*" said the shrewd old man.

Treatment by sucking is generally repeated several times before the *chizo* is extracted and spat into the corn husk. I was present when patients undergoing the treatment called upon Urbano, of Mitla, and upon Margerita, of San Baltazar; but the treatment I was not allowed to see, for reasons obvious enough. Why give an opportunity to a disinterested outsider to observe your chicanery?

Urbano's patient was a young man whose right arm and hand had become so stiff he could not close his fingers, a surprising condition explicable only as due to *chizo.* The witch would be a fellow townsperson, but no effort to identify him or her would be taken. As far as I could learn no witch baiting ever occurs. Not even at San Blas, Tehuantepec, where the *curandero* himself is described as a witch—he sends the *maldad* into you to have you go to him to suck it out. In other cases, on the Isthmus, doctor and witch were identified.

Margerita's patient was also a young man, suffering from some form of hysteria—he lay for a long time on his *petate* moaning and jerking his legs. His wife held his head, stroking his neck and shoulders. They came from Matatlan, twelve miles or so across the mountain, for the treatments, and later when I rode through Matatlan I heard the story as told by the town gossips. After the young man had left his first wife for a younger woman, he was walking along one night when he was beckoned to by somebody he took to be his former wife. He followed the woman, who led him off to a *barranca* and left him. Ever since he has been stricken.

This hysteric was frightened by a *matlansiwa,* according to Eligio, a being who takes the shape of a man or woman to lead you astray, particularly the shape of some one you have been attached to.

There are other forms of fright, naturalistic forms, generally through animals, a bull, a mad dog, a snake, which also require special treatment. The symptoms are always much the same—sleeplessness, dreams, heaviness on awakening, apathy or listlessness, no ambition, loss of appetite. The symptoms rarely develop at once, but in a month or two, or even in a year or two. To diagnose the cause of fright, copal is burned in water. On the under side of the copal will be found a picture of the cause of fright—a snake, a dog, a drunken man, etc. That the spirit may return, *para que regresa el espíritu,* if the place of the occurrence is not too remote, the *curandera* goes there with the patient, burying an egg, pumpkin seeds and fourteen little *tortillas*—at least this is one form of the offering. In some places a chicken is offered. On the return home the *curandera* beats on the ground with a stick, calling out, *"Ven! Llevantate!"* Now in the house of the patient the two flower vases are removed from the house altar to the ground, and filled with green reeds. Near them is placed some copal in a small bowl of water. The copal is set afire and on it is sprinkled little bits of *shki'bal,* which is the nest of a bee made of grains of sand gummed together with resin. Now the *curandera* takes a mouthful of water from a gourd and spurts the water onto the ground. On the moistened place she makes a cross with her finger-nail. Again she spurts water from her mouth. She slaps her right hand on the cross and then on the chest of the patient, *"Ven! Llevantate!"* Thrice she does this. Then the patient drinks the water from the bowl containing the copal together with an infusion of the herb called *verba de espanto* which has been well ground up and strained.

The *curandera* proceeds to *llamar las cuatro esquinas.* Into each of the four corners of the patient's house she carries a small jar, clapping its mouth with her hand, and calling into it in a low voice, *"Ven! Llevanta! Yo te vengo a traerte. Corre! Ven!"* Thrice she makes the circuit of the corners.

I have been describing Isidora's treatment for fright, *espanto.* In Urbano's treatment there are some other details. The cross traced on the ground is filled with the blooms of hollyhock. With *aguardiente* in his mouth Urbano sucks the patient's arms, passing his lips lightly along the flesh, and he massages the body with *aguardiente.* Into the copal water for the patient to drink, after calling the corners, go a plant which is "stronger" than *verba de espanto,* also, besides the *shki'bal,* a "red bee," probably the bee that makes the nest.[2]

The use of copal and bee nest and possibly the offering at the place of the fright seem to be Indian features, and the notion of sickness from fright, whether or not it is originally Indian, is readily adopted by Indians, witness its prevalence among our Pueblos; but whether the calling in the four corners and the general ideology of the spirit being temporarily lost are Indian or Spanish, I am in doubt. I would like to hear of European parallels, if there are any.

That curing with egg is European there is no uncertainty, particularly in the case of *mal ojo* or *ojo,* the usual reference to the evil eye. I had complained of indigestion to Agustina, so she gave me a raw egg to carry all day next my stomach, as exacting an instruction as ever I had from a doctor. On my return to the house at the foot of the pyramid-perched *calvario*—Agustina's neighborhood together with her house, built with stones from the ruins, are, like her practices, a compound of old and new—Agustina bids me pass my egg over my entire person. Then, holding the egg over a small bowl of water,

[2] It belongs to some genera of the solitary bees. The nest specimen I obtained for identification contained brood cells stored with pollen.

she touches the brim in four places, in sign of the cross, and breaks the egg into the bowl. She exclaims and points to a reddish spot on the egg and to a bubble in the water. The bubble indicates *ojo,* the red spot, stomach trouble affecting the heart. I must return to-morrow for her to rub my stomach with egg and *aguardiente.* The egg she has divined with she is going to bury.

Does Agustina believe in her cures? Probably, at least in part. She is a forceful, self-confident personality, rather kindly, with an eye, however, to her main interest which is her income. But she does not overcharge, according to the townspeople, whereas Urbano, her chief rival, is considered both avaricious and unscrupulous. He believes less in himself. Given his somewhat sardonic humor, I shouldn't wonder if he did not believe in himself at all—except in his ability as charlatan. He looked at me very quizzically indeed when first I asked him if he could suck. "Do you believe in that?" asked his eyes, if not his mouth. His wife, Petronilla, who acts as his assistant, is the avaricious one, and is much the greedier of the two. As for son and daughter, their attitude towards the professional activities of their parents is suspiciously frivolous.

I took Urbano rather lightly myself until one day I saw him treat two infants. His hands were gentle and his manner kindly. One infant had a sore (*granos*) on the cheek, which Petronilla was dressing with a dark green paste. Urbano applies the leaves he has just gathered, and the mother binds up the face and head, quieting the protesting baby by giving it her breast. The baby is very emaciated—a case of *aïre,* the baby has a violent temper, crying a great deal, and at such times *el aïre se pega* and the eruption results. The other infant is fat and healthy looking, but it has been vomiting and so is to be sucked for *ojo.*

"Do you want to suck it?" asks Urbano, the joker.

"No, I would rather see how you do it." He takes a mouthful of the *aguardiente* the mother brought him and spurts it over the child's right arm. With his finger he traces a cross and then, sucking gently, he passes his lips along the fat little arm. Then the same for the left arm. He sucks both sides of the forehead, both sides of the neck and then the chest. After washing his fingers in a gourd of water, he puts them down the child's throat, five or six times he does this, bringing up a little saliva which he washes off. This sucking, by the way, whether for *ojo* or *espanto,* is quite different from that for *chizo,* when something has to be extracted.

On her own healthy grandchild Isidora gave me a demonstration of how she, too, sucked for *ojo.* It was much the same as Urbano's way. Before sucking she massages the child with an infusion of leaves of the *peru* (acacia) and the herb called *ruda,* and then with table oil. For *chizo* Isidora does not suck. To draw blood or pus she uses a cupping glass, bought at an apothecary shop in Oaxaca. Isidora prefers Spanish survival to Indian!

Isidora is quite a different type from Urbano, or from Agustina. She is a nurse *par excellence,* looking after people rather than exploiting them. Taking care of life appeals to her. In her courtyard is a corral of sheep and goats. She keeps a flock of pigeons and much poultry. To see her warm a lamb or kid or quiet a frightened pigeon or scolding hen—the birds are constantly in and out of her room—or give her grandchild a bath, is a pleasure, so firm and gentle are her hands and spirit.

Throughout the profession there is a considerable use of herbs, leaves, roots, etc.,[3] but Isidora's pharmacopeia is much the largest I saw. It contains herbal remedies for indigestion of all kinds

[3] Compare Redfield, pp. 158–160.

—loss of appetite, stomach-ache, constipation, diarrhea—and for headache, bruises, gonorrhea. There are emetics and cathartics, abortives, poultices, ointments; also alleviatives for whooping-cough and measles, two epidemics very fatal to children among the Zapotecas, and even for smallpox.

For rheumatic pains Isidora massages with mountain lion grease. For ant bite she prescribes the saliva of a pregnant woman; for bloody vomit, a cupful of burro blood; for sore eyes, an infusion from the umbilical cord of the new-born, a remedy widely known.

The sweat bath, *temazcal,* is used primarily by the Zapotecas during a confinement, but *curanderos* may prescribe it also for various ailments, in women and men. José Martínez had ordered one for a male patient suffering from earache the day I visited the old man in Matatlan.

Old José was unusually garrulous; he told among other things of how to catch a witch, by spilling the tiny seeds of *Brassica nigra* around the house which the witch has to stay to count, or by transfixing her by throwing water or urine and anthill sand at her. She will confess and die of shame. "If you kill her, you kill her." José also told of the tricks of spiteful lovers, how to make a woman's face break out in pimples or make her dry up and die. José had a patient once with a bad leg which he said had swollen because the young man had turned Protestant.

Isidora is quite as well versed as old José in charms against witchcraft and in spite charms, also in love charms, but I got the impression from her and from others that for such charms the *curandero* is not much appealed to, they are a matter of general knowledge or of knowledge within the family.

Divination is a distinctive function of the *curandero.* It appears to meet a wide-spread and deep-seated need in Oaxaca[4] and probably throughout Mexico. Cards are, I suppose, the most common medium, but excepting the divining with basket and scissors which I saw at San Blas, Tehuantepec, the method I made a point of observing was throwing corn (*tirar maïs*).

The *curandero* of San Blas, Benino Cabeza or Tío Niño, I had heard of in Mitla; once Eligio had gone to him for news of a horse lost on a trading trip. Benino told Eligio that the horse had been stolen and in his mirror he showed the thief. I had lost some beads, I told Benino, and I wanted him to *sacar la suerta de canasta.* But Benino urged cards, and got out a manual of necromancy, reading me a paragraph about Solomon and the Queen of Sheba to divert me from the idea of the basket method. It was not until I made him laugh by describing scissors with my fingers, I had forgotten the Spanish word, that he gave in. "*Que alegre!*" he chuckled, patting my knee. Into the center of the under side of a flat basket he sticks the points of a pair of scissors, then, placing his thumbs not through but under the finger loops of the scissors, he raises the basket which by an imperceptible motion of his thumbs on the scissors he makes revolve, letting it drop from his thumbs when as he talks he mentions the answer desired. "Were the beads lost in the house or in the street?" At *street* the basket drops. "Were they stolen or merely lost?" *Lost,* drops the basket, and so Benino after all does not have to show me the mirror trick, the clever rascal! Before each spin of the

[4] Because I wore a kerchief around my head instead of a hat, I was frequently taken for a fortune-telling gypsy, Húngara, and asked to divine, generally about love affairs. I recall especially a pitiful appeal by a woman sitting next me on a park bench in Oaxaca. Her *señor* after living with her seven years and begetting a daughter, left her two years ago. She was *muy triste,* she said, thinking of him all the time. She wanted me to divine for her if he would return to Oaxaca and to her.

basket Benino mutters a prayer, addressing "*El Espíritu de Canasta,* you who know all parts of the world."

Benino assured me that his basket method of divining was not learned from the book, nevertheless all of it is obviously Spanish. On the other hand, divining with corn, a practice unfamiliar on the Hispanicized isthmus and in the more Spanish parts of the country, is, I incline to think, of pre-Conquest provenience. In general the method of throwing corn, *tirar maïs,* is to shell out a number of grains from an ear of corn and throw them on to a *petate,* divining from the figures or positions the grains make or take, or when the grains are blackened on one side, from the whites or blacks that fall uppermost.

In this general scheme there are many minor deviations of some interest. José Hernández, of Matatlan, shells out four grains of white corn, blackening one side of each with soot collected into a piece of corn husk from the bottom of a cook pot. He throws the grains onto the *serape* he has spread out, throwing four times to answer my question—was I to marry again? Yes, said the corn, and it would be a good marriage.

"How does the corn show this?"

"Because the grains turn up mostly black."

I tell Eligio to put a question and he asks whether he has any enemies. None, again because the grains turn up black. This time old José has thrown six times. José had been out on a case when we called, and as they were preparing the sweat bath, the fire sparked out—a sign of visitors, said José, and just then his wife arrived to tell him we were calling at his house. He believed the fire could divine and as he believed in the fire, just so, he said, he believed in the corn. And I think he did.

José Martínez, of San Miguel Alvarrados, was far less convincing, for one thing because he talked continuously to his wife about the meaning of the throws, to create an atmosphere of credibility. He shells fourteen grains from an ear of yellow corn, using a bit of charcoal to blacken one side or rather the notch in the grain. He places the grains on the *petate,* black sides up, and over them makes the sign of the cross, saying, "*En nombre del Padre,*" etc. Then looking towards his altar, he crosses himself. He gathers the grains into his left hand, breathes out on them and mumbles a prayer. I catch references to La Trinidad, San Pablo de Mitla, San Antonio. He transfers the grains to his right hand, shaking it and throwing onto the *petate.* Yes, my children are all well, several throws make this clear. This time Eligio has an enemy—because he is with *esta señora.* He should be very careful. Eligio learns later from another townsman who had listened in that José was under the impression that he, Eligio, was my *novio,* and the enemy referred to was a supposititious husband.

In San Baltazar I was in luck when we called on Rosa Hernández and asked her to throw the corn. The unhusked ear she took from her store proved to be a double ear, at which she and her son exclaimed, and she treated the corn ear as I had seen her behave towards the great Cross of Mitla, when I first met her on a pilgrimage, holding first the right cheek to the corn ear and then the left, and then kissing it. Plainly this kind of double ear which is used for seed corn and is a token of abundant crops has a fetichistic or sacrosanct character. At San Domingo Alvarrados I found that the flour for the bread offering made to La Tierra in time of drought was made from the double ear. (In Zuñi, New Mexico, the double ear is referred to as mother and child, and at Laguna it is fed to stock to make them reproduce generously.)

Well, from her double ear of corn

Rosa shells out twenty-two grains; half she places in my right hand and half in my left, crossing each hand. She directs me to cast each handful into a small bowl which she places on her altar. She makes the sign of the cross on the rim of the bowl and then waves it around all the pictures of the saints on the altar. From the pictures she motions towards the bowl with both hands—the same drawing-in motion I had seen her making at the cross, from the four directions. Removing the bowl from the altar to the *petate* she repeats the drawing-in motions—from the altar, from the north side, from the west. Now she covers the bowl with another and shakes the grains up and down, three times. She uncovers the bowl and studies the grains intently. She pours all the grains into my right hand and bids me make the throw onto the *petate*. Several times I have to throw, and I am told that my mother and one son are thinking of me, that I am going home soon, that I am to live a long time. As for Eligio, poor fellow, he has enemies this time, too, and his wife is grieving about him. For him the whole ritual had been repeated and fresh grains shelled, sixteen.

Evidently this was a haphazard number as it was in all the other cases of divination I saw, except the divination by María García, the mode of which she had learned among the Mixtecas.[5] María has to have exactly fourteen grains to compose her divinatory picture (Fig 1).

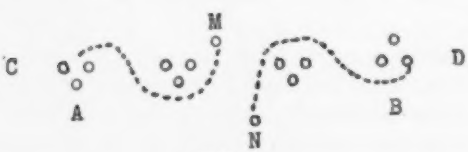


FIG. 1.

The grains are from an ear of black corn and she groups them with precision on a very small *petate* in front of her. She carries the single grain at M to the group at A along the curve indicated, and the grain at N to the group at B. The four now at B she carries to C, and the four at A to D. From the group at C she picks up one grain, placing it near C, and to it she adds one grain from the group at D, leaving Fig. 2. She holds


FIG. 2

her mouth down near D and blows on the grains to make them scatter. . . . I ask three questions. Are my children well? Shall I remarry? Is my married daughter to get a divorce? For each question she rearranges the grains and blows, and she asks a few questions herself. How many children have I? How long widowed? Has my daughter children? The corn tells her that two sons are sad, thinking of me; the third is selfish and disobedient. They are going to abandon something important; I should go back to look after my affairs. I have a lover the children do not like. I had better not marry him, life with my family would be unhappy. I get angry quickly . . . I shall live long. . . . My daughter's husband has other loves and charges her with having lovers, a calumny. But he is watching her. Unless she have lovers, he can not divorce. Their life is a continual quarrel. Presenting imaginary situations to a soothsayer is not a bad way, I began to think, of observing social attitudes.

Such observation I had further opportunity to make at Agustina's as I listened to her divinations for some pilgrims to Mitla during the fiesta of San Pablo. The first client, from San José Pobresa, was a young woman carrying a baby. She was a widow and could not take care of her cows properly. Somebody was stealing from the herd. What should she do to check the robber? She was to offer two candles, one in the

[5] But from a "Spaniard," she said.

Calvario, one at the cross in the atrium, to Las Animas, the Souls; and in October during the fiesta of La Virgen de Jucila at Tlacolula, she was to visit Agustina again. Meanwhile Agustina herself would pray to Las Animas, pray that the robber turn to robbing the rich instead of poor widows. (In short, become another Robin Hood!)

Agustina's grains of yellow corn are already prepared. She pours them out from a tin box, about a hundred dry grains. She passes them from hand to hand, about eight times, praying over them, and in conclusion, cupping them in both hands, she breathes out hard on them, from the throat, moving her lips in a circuit. (Later, Eligio describes this breath rite as saying, "*En nombre del Padre, del Hijo, y del Espíritu Santo,*" but, in imitating, Eligio blows from his lips. The expulsion from the throat is, I think, Indian.) Now with all the grains in her right hand she prays again and breathes out again. She moves her hand forward and back and throws the grains onto the *petate*. She studies the position of the grains, prays again, then tells what the corn is saying.

There follows the prayer made while holding the grains before casting. (Later she dictated the other prayers also, but they were unintelligible to Eligio as well as to me.)

Eres maïs, eres sabiduría,
Explica me hoy en este día
Para poder explicar.
Eres planeta de flor,
Eres la rueda de la fortuna.
A llegar en la mata
Les convenca al instante.

Ten centavos is the charge for each particular divination, but dictation of the prayers cost me five pesos. And the prayer said by Agustina when she "sucks," a prayer learned from her uncle, the priest, would have cost much more had it seemed worth it to me. Her prayers appear to be as precious and costly to Agustina as prayers ever appear to be to an Indian.

After the widow leaves us, in comes a family of father and mother with her baby and a boy of thirteen, also from San José. What sickness afflicts his wife? asks the man who is spokesman throughout. All these San José visitors, by the way, talk to Agustina in Spanish, which is a more intelligible medium for them than their diverse Zapoteca dialects. The woman has pains in her chest and in her back, low down. For this, after her initial ritual and casting, Agustina prescribes rubbing the back with the warm urine of the baby, butter and lime water; and rubbing the chest with an infusion of *oja de grilla.* Also Miguel is to pay two pesos for a mass (*pagar una misa de dos pesos*). And Juana is advised to keep to herself, away from trouble-making friends—"*Las amigas van a platicarlo a su contrario y de alli empieza el pleto.*"

Miguel's elder son and daughter-in-law are living with him; the daughter-in-law is restless and wants to leave her husband. What is to be done? The corn, recast, advises that the son, whose name Agustina asks for, and his wife set up an independent household; otherwise within two or three months the woman would cease to respect her father-in-law. In time the son will become rich. For help in smoothing out the situation, Miguel is to take a candle to the church for the Corazon de María, and another for Jesus Nazarino.

After her last cast Agustina announces that a death threatens in the family. "*No de casa?*" asks Miguel very anxiously.

"*No, pero son familia.*"

Against this danger Miguel is to pay for six *responsos,* three for *Las Animas Solas,* three for *Las Animas Común,* a distinction between the souls which seemed quite familiar to him as well as to Agustina, but which nobody I subse-

quently questioned was clear about. *Animas Solas,* yes, that was a common term, perhaps it referred to those who died without any family to care for them after death; but *Animas Común,* nobody used that expression.

Miguel seems well satisfied, he repeats all he has to do and takes off his money belt to find the fee, fifty centavos. Agustina gets out some oranges, gives me one and a piece to the baby. Miguel offers us cigarettes. Later when I visit the church I find Miguel and his family on their knees before the altar rail. In front on the ground burn the candles he bought from Agustina, and six times to the *cura* Miguel pays for the prayers and asperging which constitute a *responso* for the dead. Did the *cura* know, I wondered, that he was praying to preclude a death or did *he* know the difference between *Las Animas Solas* and *Las Animas Común?* And I wondered if other *curanderos* in other parts of Mexico were such faithful pillars of the church as Agustina. If so, Catholicism in Mexico had at least one base that anticlerical legislation could not shake.

# SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

## ADVENTURES WITH ELECTRICITY IN A PARTIAL VACUUM

By Dr. KARL T. COMPTON

PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

It is no exaggeration to say that the most exciting developments in physical science during the last generation are those which have been associated with a study of what happens when an attempt is made to force an electric current through a partial vacuum. Not only have these experiments led to the discovery of the electron and to the accurate weighing of individual atoms and molecules, but they have also led to much information regarding the architecture of these inconceivably tiny yet incomparably active bits of matter. They have also led, on the practical side, to the discovery of phenomena and the invention of devices which have opened up entirely new avenues of activity and achievement. Among such discoveries may be mentioned X-rays, which have revolutionized diagnostic medicine, which have revealed those differences in molecular arrangement that determine the suitability or unsuitability of a metal for a great number of important industrial purposes, which detect the flaws in armor plate or welded joints and which in general enable us to see many things otherwise invisible. These experiments have also produced such familiar objects as the illuminated gas signs in the variety of brilliant colors which are now the striking feature at night of every city, the little rectifiers which charge your automobile batteries, much of the apparatus which operates your theater lights or your automatic electric machinery, but above all in their influence on the life and thought of the present generation, they have led to the radio tube, which has revolutionized the entire art of communication whether by wireless or by wire. It is particularly fitting therefore that in this talk on science to the radio audience I should describe some of the phenomena and experiments which have made the radio possible.

Nearly two centuries ago while experiments were being carried on with static electricity—of the kind which is produced when two dissimilar substances like wool and rubber or silk and glass are rubbed together—a peculiar difference in the behavior of positive and negative electricity was noted. I should here explain that the name positive electricity was quite arbitrarily chosen to designate that kind of electricity which is produced on glass when it is rubbed with silk, and that negative electricity is that other type of electricity which can neutralize positive electricity. Now, it was found that if a red-hot metal ball were given a charge of positive electricity it would retain this charge for a very long time, but that if it were given a charge of negative electricity the negative electricity would rapidly leak off through the air. If the ball were cold, on the other hand, there was no difference in the action of the two kinds of electricity on the ball, both being retained by the ball. Thus was discovered the peculiarity of negative electricity, that it can escape from a metal if the metal is hot.

Nothing more was learned about this

until more than a hundred years later when, in the 1880's, Thomas Edison discovered that electric currents could flow across the partial vacuum in his newly invented incandescent lamp, the direction of these currents indicating that negative electricity went out from the filament through the surrounding space to the glass walls or to any metal plate which might be placed within the bulb. This phenomenon was known as the Edison effect and was obviously closely related to that which had been discovered more than a century before.

Immediately following this discovery two German physicists named Elster and Geitel began a very extensive series of tests in an attempt to discover the cause and nature of these currents of negative electricity proceeding from hot metals. For this study there was designed an apparatus very crudely similar to a modern radio tube in that it contained a filament which could be heated by passing an electric current through it, and another electrode—and the intervening space within the glass tube could be filled with any desired kind of gas at any desired pressure. In these experiments it was found again that negative electricity could pass through the surrounding gas from a hot filament to a neighboring electrode, that the size of this electric current depended very much on the temperature of the filament and also to some extent on its material and on the nature of the surrounding gas. Hundreds of observations were made and recorded, but these experiments led to absolutely no clue as to the cause of these currents or to any definite relationship between the size of the current and the temperature of the filament and other conditions.

Now let me digress for a little while to introduce to you that smallest yet most important part of the universe, the electron. Simultaneously with these experiments on hot filaments there had been going on a very intensive study of those peculiar luminous and electric effects which occur when electricity at high voltage passes through a long partially evacuated tube. The contents of the tube are luminous with various spectral colors characteristic of the type of gas in the tube. Starting with atmospheric pressure and gradually pumping the gas out from one of these long tubes, meanwhile maintaining a high voltage of perhaps some thousands of volts applied to its extremities, there is at first nothing to observe, since the air at high pressure is a good insulator. As the vacuum improves, however, there is first observed a long luminous streamer which gradually expands until it fills the whole tube with a uniform soft glow. As the vacuum improves with still further pumping, this luminosity separates into well-defined regions, sometimes of different colors and separated by regions of darkness. As more and more gas is pumped out these luminous striations move to the positive end of the tube and disappear, while their place is taken by a different type of luminosity which creeps up after them from the negative end and finally fills the whole tube. At about this stage, moreover, the glass walls begin to glow with a greenish fluorescent light, and it is at this point that X-rays begin to emanate from the tube. Finally, if the gas is pumped out to the extent possible with our modern high vacuum pump, a stage is reached at which the current through the tube and the luminosity cease entirely. In this striking series of phenomena are to be found the essential occurrences of electric arcs, sparks, lightning, aurora borealis and all other phenomena of electric discharge through gases.

It was while searching for the cause of these electrical and luminous phenomena that Wilhelm Konrad Roentgen discovered X-rays and a brilliant group

of physicists headed by Sir J. J. Thomson discovered electrons, whose rapid motion at the high voltages and whose vigorous bombardment of molecules in their paths were the cause both of the electrical conductivity of the gas and of the luminous radiation emitted by it. These electrons were discovered almost exactly thirty years ago, and from that day to this, scientific discoveries have followed at a pace never before even dreamed of in the history of mankind.

Within a year after the discovery of electrons it had been proved that the negative currents of electricity which escape from a hot filament are constituted simply of a stream of electrons. Another brilliant young English physicist named Richardson, as his doctor's thesis put forward the theory that these electrons were simply evaporated out of the metals by essentially the same processes which are involved in the evaporation of a substance like water. He worked out this theory quantitatively to give the relation that would be expected between the rate at which this evaporation occurred and the temperature of the metal, or in other words, the relation between the electric current and the temperature, and then he carried on a series of notable experiments which proved the accuracy of his theory in a remarkable fashion. His theory is found to be accurate from the smallest to the largest currents which have been measured coming from hot filaments, a range in which the largest currents are at least a thousand, million, million fold greater than the smallest.

As I have heard the story of the first invention underlying the radio tube, it is this. Richardson was reporting the results of his theory and experiments before one of the British scientific societies. In the audience was a well-known electrical engineer named Fleming. During the address Fleming conceived the idea of using this phenomenon to produce an electric valve, that is, a device which would allow electricity to flow in one direction through the tube but which would prevent any such flow in the opposite direction. This is possible, you see, because negative electricity comes out of a hot filament but positive electricity does not, consequently electricity can flow in only one direction from the filament. Fleming sketched his idea on the back of an envelope and after the lecture propounded it to Richardson, who agreed that the idea was feasible. On the basis of their discussion Fleming took out his patent on the so-called Fleming valve, a valve which, when connected in the antenna circuit of a receiving wireless set, would convert the alternating current of the radio wave into a direct current which could be detected by suitable instruments.

About a year later than this, that is, approximately twenty-five years ago, Fleming discovered that this valve could be much more sensitive as a detector for wireless waves if a sufficient voltage were applied between the filament and the neighboring anode to produce a slight ionization of the small amount of residual gas in the tube—in other words, to speed up the electrons coming from the filament sufficiently to break up gas molecules with which they happened to collide. This was the origin of the so-called "soft" detector tube of the radio art up to a few years ago.

From that time on improvements and inventions have been numerous and rapid. A great step forward was taken when De Forest introduced the grid between the filament and anode of the Fleming valve and showed that currents could be amplified and controlled according to the incoming signal from the antenna by the voltage impressed from the antenna on this grid. These audion tubes, so-called, while sensitive, were somewhat erratic, and principally

through the researches of Langmuir a new tube came into being which had all the appearances of the old one but differed from it in having the gas pumped out of it by such improved methods that the amount which inevitably remained was too small to affect the operation of the tube, so that instead of depending on or being affected by gas ionization accompanying the flow of electrons from the filament, the modern tube is made as free from this as possible. Under these conditions the detector action of the tube is due to another phenomenon quite different from gas ionization. Finally, to complete the major aspects of the story, I must mention the additional great improvements which have come through a discovery of the most suitable materials for use as filaments, materials which will give a steady flow of electrons and which will give a sufficiently large flow at the lowest possible temperature. The present tubes almost universally contain filaments of tungsten coated in an interesting way with a layer of the rare radioactive element, thorium, only one atom deep over the surface—again, a discovery due to Langmuir.

In this brief talk I have dwelt principally upon the development of the radio tube, but have mentioned in passing the X-ray tube, the luminous gas tube, arcs, sparks, etc. Each of these subjects has behind it a story of absorbing scientific interest; each is at the present time engaging the attention of a large number of scientists and engineers in university and in industrial research laboratories; and each is playing now and is destined to play in the future an important rôle in the electrical industry.

Our present age is often designated as the electrical age. There are many who see indications that the electrical age in the next generation may develop into one which is to a large extent dependent on devices which have come from a study of the discharge of electricity through gases.

It may be interesting to amplify just a bit this last statement. In the early days of electrical engineering, that is, about fifty years ago, electric power was generated, distributed and used in the form of direct current, that is, the electric current always flowed through the wire in the same definite direction. Soon, however, it became evident that it was advantageous to use very high voltages for transmitting electric power over great distances because the loss of power in the wires is less at high voltage than at low voltage. By means of a transformer, electric current can be changed from low voltage to high voltage or *vice versa*. However, it is only alternating currents which change their direction many times a second, which can thus be modified in voltage by means of a transformer, and for this reason the present-day electrical industry is entirely an alternating current industry, except for a few particular purposes for which direct current is essential.

Within the past few years, however, an instrument based on electrical discharge through a rarefied gas in a bulb has been developed by Dr. Hull, of Schenectady, which makes it possible to change direct currents from high to low voltage or *vice versa*, and if these instruments, known as thyratrons, prove as practical as now seems probable, the next dozen years may see a return of the direct current in power transmission systems. Such a development would simplify certain problems of insulation and mark a very decided advance in the economy and efficiency with which large amounts of electric power may be handled.

These few illustrations which I have described will, I hope, prove to your satisfaction that adventures with electricity in a partial vacuum have been both interesting and of practical value.

# RADIO AND THE OUTER ATMOSPHERE

By Dr. EDWARD O. HULBURT

SUPERINTENDENT OF THE HEAT AND LIGHT DIVISION, U. S. NAVAL RESEARCH LABORATORY, WASHINGTON, D. C.

I WISH to describe some recent advances in the knowledge of the outer atmosphere of the earth which have resulted from the wide-spread development of radio telegraphy. In 1901 Marconi succeeded for the first time in sending wireless signals across the Atlantic Ocean. Lord Rayleigh, the renowned English physicist, immediately asked how the wireless waves traveled such long distances, for they could neither go through the earth nor without help bend very much around the curvature of the earth. In answer Professor Kennelly, of Harvard University, and Professor Heaviside, in England, suggested that the air in the high atmosphere might be sufficiently electrified to reflect the wireless waves. Thus the waves would be guided around the bulge of the earth traveling between the surface of the land or sea and a more or less parallel reflecting layer overhead. During the next twenty years the suggestion remained hardly more than a suggestion in spite of the fact that the use of radio waves expanded at a very rapid rate. Little progress to a better understanding of the behavior of the waves took place. Some new facts were needed. These came in the years around 1920 to 1924 with the discoveries of the remarkable properties of the short wireless waves below 50 meters in length. It was found that the short waves could be transmitted long distances, thousands of miles or even twice around the earth, with relatively little power. Curiously enough at near distances they could not be used. After leaving the transmitter they went up into the air, skipping over the nearby region, and came down to the earth again several hundred miles away. The "skip distance" was regarded as almost the first direct experimental proof of a reflecting region overhead. The Kennelly-Heaviside layer changed from a theory to a reality.

The behavior of the short wireless waves was investigated by the far-flung organization of the United States Navy in an extensive program of measurements carried out with the cooperation of the radio amateurs all over the world. The skip distances were found to be greater as the wave-length was made shorter. They were first measured carefully for four different wave-lengths—16, 21, 32 and 40 meters—giving four points on a curve. From four points on a curve a mathematical physicist can construct a new theory of the universe. Not quite this was done in this case, but from the four points it was possible to calculate the maximum density of electrification in the reflecting layer and the height of the layer above the earth. The height came out about 100 miles above sea-level, and in the densest part of the layer there were about 300,000 electrons per cubic centimeter and a large number of ions. An electron, as you all know, is the smallest unit of negative electricity, and an ion is a molecule, or an atom, which has become charged with either positive or negative electricity. The charged particles are spoken of as the "ionization," and an ionized gas is one which contains a number of such charged particles. In the meantime other experimenters were determining the height of the layer and the electron density by measuring the time for pulses of radio signals to travel up to the layer and back to the earth

again, and by measuring the angle of the downcoming waves. The values obtained by these methods agreed with those of the skip distances. Thus it is now an established fact that all radio signals, broadcast programs, etc., which are received at distances beyond 50 miles from the transmitter have traveled 100 miles skyward and have bounded back to the earth again.

The skip distances and the ranges of the short waves were measured for night and day and for summer and winter conditions in various parts of the earth. The electron and ion density was found to be greatest at noon, to grow less all night and to be less in winter than in summer. The height was greater at night than in the day. The skip distances and the behavior of wireless waves in polar regions will be known as soon as the analysis of the large amount of valuable data brought back by the Byrd Expedition is completed. Their data include a record for almost every hour of the day for over a year on the Antarctic ice shelf. The radio phenomena of polar regions were of course not known when Byrd made his flight over the South Pole. The plans for the flight called for continuous radio contact between the plane and Little America. Because of the small power available, short waves had to be used. The Navy's skip distance and range tables for winter day conditions were studied carefully, and a 68-meter wave was chosen for the first 200 miles, which was shifted to a 45-meter wave at the 400-mile mark and then shifted to a 34-meter wave for the remaining 380 miles to the Pole. The schedule was executed, and it turned out that communication was excellent throughout the polar flight except for a weak period of 30 minutes or more after the shift to the 34-meter wave. The skip distance of this wave was slightly greater than had been estimated, and the plane had to fly some distance before it entered the zone of good reception.

After the fact had been established that ions and electrons existed in the high levels of the atmosphere from 50 to 150 miles one wondered what was the cause of the ionization. Since the ionization increased during the daytime and dwindled away at night it seemed pretty certain that the sunlight produced the ionization, especially so since ultra-violet light is known to ionize the gases of the atmosphere and since the sun emits ultra-violet light. Before the matter could be examined, however, one had to know what the atmosphere was like in these outer regions, regions above the blue sky—for most of the blueness comes from levels below 30 miles—regions visited only by meteors and wireless signals, regions where the air is very attenuated like the vacuum tube of the laboratory. The entire physics of the high atmosphere had to be worked out as well as possible, the wind velocities were estimated from the drift of the meteor trails, the day and night temperatures were calculated from the heating by the sun and the cooling by radiation at night, etc. Tables, theoretical of course, were prepared of the amounts of the various gases, nitrogen, oxygen, helium, etc., in the air to heights up to 200 miles. The daytime temperatures at levels above 70 miles came out to be about the boiling-point of water, and the night temperatures to be around 100 degrees below zero Fahrenheit. The ionization to be expected from the ultra-violet light of the sun was then calculated and was found to agree with that derived from the skip distances and other facts of radio. It was concluded that the Kennelly-Heaviside layer is caused by the solar ultra-violet radiations.

The ionization led to the explanation of a fact of the earth's magnetism which had long seemed very puzzling. The

analysis of the magnetic maps of the world by the usual gaussian harmonic method had shown that 98 per cent. of the earth's magnetism came from inside of the earth but that 2 per cent. was due to some unknown cause outside of the earth. It was seen from ordinary electromagnetic theory that the ions in the high atmosphere under the influence of the earth's gravitation and magnetic fields would drift, the positive ions going eastward and the negative ions westward. This constitutes an eastward electric current in the high atmosphere flowing continually around the earth, the current being mainly in the tropical latitudes and becoming weak at high latitudes. The current amounts to about three million amperes. It causes a magnetic field exactly equal to the unexplained 2 per cent. of external origin.

If the ultra-violet light of the sun is the cause of the ionization in the outer atmosphere one might expect the ionization to dwindle away almost completely in polar regions during the long Arctic winter night. But experiments with round-the-world radio signals and with other long distance signals, as well as more recently those of the Byrd Expedition, have shown that certain waves traverse polar regions during the winter night, indicating that ionization does exist there. One could point out, however, that in the outer fringe of the daylight atmosphere—at heights above 200 or 300 miles, regions verging into interplanetary space—molecules and atoms are continually sprayed away to great distances 30,000 miles or more from the earth. When these particles are ionized by the sunlight they do not fall vertically back to the earth, but are caught on the earth's magnetic field and fall along the lines of magnetic force into the polar regions. In this way the dark polar latitudes are kept supplied with ionization distilled in from the lower sunlit latitudes.

Thus far, although we have not said so, we have been speaking of the outer atmosphere during a time of calm. We shall now say a word about the storms which occur there. Magnetic storms have been observed systematically for the past 80 years. A magnetic storm is a small affair from some standpoints; for example, it is too small to trouble appreciably a mariner's compass. It causes, however, a tremendous wiggle in the curve which is traced continuously by the sensitive instruments of the magnetic observatory. And what perhaps is of more practical interest, the short-wave wireless signals were often found to be wiped out and the short-wave communication channels rendered inoperative during a magnetic storm. Magnetic storms differ from ordinary storms in that they occur at the same instant over the entire earth. They may last a few hours or several days; there may be only 10 or 20 storms during some years and as many as 50 or 100 during other years.

It has long been known that most magnetic storms are due to an outburst of some sort from the sun, but just what the eruption is like or where it is on the solar surface has not yet been discovered. The surface of the sun is like a burning prairie and is covered with countless flickering, blazing flames. Outbursts and upheavals of flaming gases occur continually, but no particular type of eruption has yet been identified with certainty as the cause of the terrestrial storm. Again it has been the behavior of the short radio waves which has given a clue to what happens on the earth during a magnetic storm, and what happens is a storm in the high atmosphere. To make a long story short the general idea of what takes place is as follows.

The solar outburst is a flare of ultra-violet light which usually blazes up to full intensity in a few minutes or an

hour, and dies away more or less irregularly in a day or so. The flare is probably difficult to see because most of its light, being in the far ultra-violet part of the spectrum, is absorbed in the high atmosphere and does not penetrate through to us. The effects of the absorbed radiation are interesting. The ionization in the upper atmosphere is increased and a million amperes or so are suddenly added to the three million amperes encircling the earth. The magnetic effects of the additional current are simultaneous over the earth and constitute the magnetic storm. The solar flare heats the high atmosphere in the daytime, causing it to expand outward. Calculation showed that the ionized layer should be lifted up about 50 miles during an average storm, and measurements with radio signals showed that this was so, increases in height of 30 to 70 miles being observed during magnetic storms.

The sudden heating of the daytime high atmosphere by the flare causes violent winds and turbulence in the ionized layers, so that the ionization is blown about like storm clouds or the waves of the sea. It becomes no longer a good reflector of the short wireless waves. During the night the disturbance dies down and increases again with the dawn if the solar flare is still in action. The short-wave channels of the United States Navy furnished evidence in favor of this view. To give one case: a magnetic storm began around noon, Eastern Standard Time, and continued for two days. The Atlantic seaboard and transatlantic short-wave circuits became inoperative the first day, recovered somewhat during the night and found trouble again with the dawn of the second day. Meanwhile the Pacific circuits, which were in the dark when the storm began, experienced no difficulties until the dawn and then showed weak signal intensity and violent fading which cleared up the following night.

The ultra-violet flare increases greatly the high flying ions which are sprayed away from the outer fringe of the high atmosphere. The distillation of the ionization into the polar regions therefore is increased. This causes the aurora displays, which are known to occur during magnetic storms. But here I must stop—for the time allotted to this talk is limited—with just a mention that there is a connection between magnetic storms and the breaking up of comets and the variations in the zodiacal light.

# INDUSTRIAL REVOLUTIONS

By WATSON DAVIS

MANAGING EDITOR, SCIENCE SERVICE, WASHINGTON, D. C.

It is not a governmental or political revolution that we are interested in this afternoon, but the quiet, gradual revolution, perhaps I should say evolution, of industries that has changed the physical environment in which you and I live.

Think back to the days of your own youth, the pre-radio days, the times when the airplane was a novelty, when telephones and automobiles were marks of distinction. It does not take a very long memory to remember when all silk was made by silkworms, lacquer was not made from cotton and every one expected all steels to rust.

Fate has not been kind to those industries that have been content to let well enough alone. Buggy factories are not paying extra dividends. The pace of the last few decades has been swift to those who have lived through them, but

it will seem even speedier to the historian with perspective.

Like it or not, the conditions under which we live to-day are vastly different from those under which our grandfathers were raised. Popular philosophers and alarmists at times set up cries against the cruelty of this machine age to its human subjects, to traditions, to ideas dear to conservatives of civilization that was. We may expect and respect them even if we do not agree with them.

There is little profit in complaining or praising, whichever is your inclination, without knowing whence and how this new age of ours came into being.

History as it used to be taught in the schoolbooks was largely a matter of kings and queens, generals and battles. It was a chronicle of the superficialities of politics and wars, flavored by the national partisanships of the country whose sons and daughters were reading the history books.

Napoleon set Europe aflame, but history may well give a more lasting place to the inventor or inventors of the match. In their influence upon the world, obscure inventors or scientists who worked in a garret have been more powerful than kings and presidents, although they may have suffered poverty and even ridicule in their own time.

From such beginnings the industrial revolution of to-day has been dreamed. The industrial revolutionists, as these pioneers of to-day's industrial commonplaces may be called, have served mankind without regard to the limitations of geographical boundaries and the passage of time itself.

Where would the automobile and airplane be to-day without the use of the cycle of Otto, German engineer? Where would the electrical industry be to-day without the scientific discoveries of Faraday, Englishman, and Joseph Henry, first secretary of the Smithsonian Institution? What would we do for tires and a multitude of other necessities without the vulcanization process of Goodyear? How could we do without the speedy communication of to-day made possible by the telegraph of Morse and the telephone of Bell? How uninviting our winter dinner tables would be without the success of the pioneers who put food in cans and kept it from spoiling.

These industrial revolutionists, quiet earnest men for the most part, often impractical and foolish in the eyes of their critical standpat contemporaries, are the true fathers of our industrial age. Their memory is in a hall of fame that needs no array of statues.

Do not for a moment conclude that the industrial revolution is over or even waning. It began when man first made fire; it has gained momentum speedily in the recent decades; it whirls about us, and it will rush on into future years.

We have among us to-day a few men whose ideas and genius, mixed often with a dash of luck, have influenced our civilization profoundly. Often their names are virtually unknown to the public, and the man in the street benefits from their labors without knowing whom to thank if he should feel so inclined.

With apologies to Mr. James W. Gerard, who recently picked a list of "rulers of America" which was conspicuous for its lack of government officials, let me assert that while the chairmen of boards of great corporations may rule our financial and even our political destinies, they do not mould our civilization.

Scientists and technologists, "industrial revolutionists," dead and living, are the individuals who are remaking our civilization. It is they whom bank presidents and industrial magnates must watch in order to safeguard their financial investments.

It is not easy to pick the industrial revolutionists among us to-day, but there are some who have seen their genius and hard work have a major effect on industry.

I nominate as to-day's industrial revolutionists:

Thomas A. Edison, who invented the incandescent electric light, who would be perpetually famous if that were his sole gift to mankind, but who pioneered in motion pictures and a multitude of other fields.

Orville Wright, joint inventor of the airplane, who was the first to fly in a heavier-than-air aircraft, an achievement that made possible the development of the air transportation of to-day.

Mme. Marie Curie, because with her husband she isolated radium, the radioactive element which has found commercial use as well as utilization in the treatment of cancer and other diseases.

Guglielmo Marconi, inventor of wireless telegraphy.

Dr. Lee De Forest, whose invention of the three-element electron tube laid the foundation of the great radio industry of to-day and who has been a pioneer in the development of talking motion pictures.

George Eastman, because he invented photographic film which made amateur photography easy and motion pictures possible.

Dr. Elihu Thomson, electrical engineer, whose researches on alternating current laid the foundation for the extensive transmission and use of electricity to-day and who is the father of electric welding, the silent builder of steel skyscrapers.

Dr. Fritz Haber and Carl Bosch, who, working for the great I. G. chemical combine of Germany, developed the production of synthetic nitrogen from the air by the direct synthetic ammonia process on such a scale and so economically that agriculture and industry are made independent of the natural nitrates of Chile.

Dr. Leo H. Baekeland, chemist, who invented bakelite, the synthetic plastic made from formaldehyde and carbolic acid, and who invented velox, photographic paper.

Georges Claude, French inventor and engineer, who devised the method of liquefying oxygen and other gases, invented the neon electric lamp and is now working on a method of obtaining power from the temperature differences in sea-water.

Frederick E. Ives, inventor of the half-tone process of illustration reproduction that is used thousands of times every day throughout the world in the printing of magazines, newspapers and books.

The group of Bell Telephone Research Laboratories engineers, headed by Dr. Herbert E. Ives, son of the half-tone inventor, who brought talking motion pictures by two processes to such commercial perfection that the motion picture industry went sound nearly overnight, who also perfected a process in television over wire and radio, and who has constantly improved the telephone.

Dr. W. D. Coolidge, General Electric physicist, who invented the X-ray tube in common use which bears his name, and the tungsten filament electric light.

Dr. Frederick Bergius, German chemist, who invented the hydrogenation of coal process by which oil can be made from coal and which is now being used in the refining of petroleum, and who is now developing a process for making edible carbohydrates from waste wood and other cellulose products.

Dr. Michael I. Pupin, who rose from immigrant to inventor, because of his invention of loading coils for telephone lines which makes possible conversations across continents.

Dr. F. G. Cottrell, who invented the

electrical precipitation of fine dust and other particles which is used to such advantage by smelters, cement plants and other industries that otherwise would pour out wastes that would pollute the air we breathe.

Dr. William M. Burton, whose process of cracking petroleum has made possible the production of enough gasoline to run the automobiles of the world.

Sir Charles Parsons, the British engineer who invented the steam turbine.

Sir Robert A. Hadfield, English metallurgist, who pioneered in the production of manganese and silicon alloy steels.

H. Brearley and Dr. W. H. Hatfield, English metallurgists, who pioneered in the production of stainless or rustless steels which now have wide commercial use.

Dr. Irving Langmuir, General Electric chemist, who invented the gas-filled electric lamp and atomic hydrogen welding.

The group of American chemists, including Professor H. P. Cady, of the University of Kansas, Dr. R. B. Moore and Dr. F. G. Cottrell, then of the U. S. Bureau of Mines, and their associates, who during the World War extracted from natural gas the sun-element, helium, hitherto known only as a rare inert elemental gas, and supplied it in such quantities that it now floats large airships.

C. Francis Jenkins, inventor, who pioneered in motion pictures and radiovision.

Chemists of the du Pont companies, who developed a new kind of paint, pyroxylin lacquer, and made it possible to paint automobiles with a cellulose compound.

Chemists of the I. G. Farbenindustrie A. G., Germany's dye trust, who produced new dyes, drugs and other synthetic organic chemicals.

Dr. Robert M. Yerkes and his psychological associates, who during the war devised the army mental tests which demonstrated to industry the utility of such tests.

Clifford W. Beers, "the mind that found itself," who, because of his experiences in an insane asylum, founded the mental hygiene movement which is rescuing thousands from mental illness.

Dr. S. M. Babcock, University of Wisconsin chemist, whose test for butter-fat content of milk put the dairy industry on a firm scientific basis.

Dr. L. O. Howard, veteran government entomologist, who long led America's war on the insect and who aroused the nation to the necessity of fighting insect invaders which menace health, crops and live stock.

Professor George H. Shull, botanist, who showed how to breed corn of higher yield that has meant millions of dollars to American farmers.

Dr. John Mohler, chief of the U. S. Department of Agriculture's bureau of animal industry, whose vigorous fight against foot-and-mouth disease of cattle has subdued that scourge and saved the live-stock industry untold loss.

Dr. Marion Dorset, Department of Agriculture biochemist, who developed methods of immunizing pigs against cholera and thus saved heavy losses in the industry of hog raising.

Dr. Theobald Smith, dean of American bacteriologists, whose work on Texas fever removed the menace of that disease of cattle, but, more important, proved that insects can carry disease.

Dr. Casimir Funk, who invented the term vitamin and called the attention of students of nutrition to early work on beriberi. This ushered in intensive research upon vitamins with resulting changes in food habits.

To this list there should also be added many pioneers in medicine whose researches have conquered many diseases, but time does not permit.

And there can not be included in this list, although perhaps there should be, the names of thousands of individuals who have aided in the birth of new ideas or perfected them so that they could do industry's work.

Great and important names in science, such as Einstein, Michelson, Millikan, Morgan, Rutherford and a host of others, are not in this list because their work, for the most part, has not yet been translated into industrial effects. That they are affecting the world's thought stream is undoubted; that even the most abstruse scientific discoveries will have industrial results in the future can not be doubted.

A decade more and it will be necessary to add to this list the names of some scientists and engineers who now are unknown even to their fellow workers. Absent from this list also are the names of those organizers and directors of research whose inspiration, planning and generalship have been as necessary to industrial revolutions as the achievements of the revolutionists themselves. Absent also, but with more reason, are financiers and capitalists who pay the modest salaries of the revolutionists or provide the funds to exploit their processes. They must derive their profits from the dividends that the industrial revolutionists make possible.

# RACE PROBLEMS AS SEEN BY THE ANTHROPOLOGIST

By Dr. FAY-COOPER COLE

PROFESSOR OF ANTHROPOLOGY AT THE UNIVERSITY OF CHICAGO, AND CHAIRMAN OF THE DIVISION OF ANTHROPOLOGY AND PSYCHOLOGY, THE NATIONAL RESEARCH COUNCIL (1929–30)

I HAVE been asked to tell you in fifteen minutes some of the most important of racial problems as seen by the anthropologist. Perhaps I should begin by assuring you that an anthropologist is not a disease, but a student of mankind. It is his task to study man in all places and in all ages. He searches for man's early ancestors in the strata of the rocks and traces his development up to the modern races. In the same manner he traces culture from its simple beginnings, more than a half million years ago, up to our present civilization. By taking this long-time view and by studying all grades of culture it is possible to gain a prospective from which we can see our own society and our own race in its proper place.

But what do we mean by race? There is much confusion in the use of the term, and we find popular writers speaking of the French race, the Aryan race or the Jewish race. Now, of course, none of these are really races; France is a nationality; Aryan is a linguistic term and several races speak Aryan languages, while the Jewish people, once a nation, now form a religious caste.

In science when we use the term "race" we refer only to physical type. We mean a people who have in common certain physical characteristics which distinguish them from all other people. Have we such types? If you stand on the street corner of any large city and watch the crowd you quickly realize that there are marked differences in the people who are passing by. By the color of skin, character of the hair, projection of the face, thickness of lips and other characteristics you realize that one is a Negro, another is a Mongolian, a third is a Caucasian. Such broad classifications are easily made, and if you have had some training you will again divide these major divisions into

subgroups which we call races. For instance, the Caucasian division contains four races—the Nordic of northern Europe, the Alpine of central Europe, the Mediterranean of southern Europe and the Hindu of northern India. If time permitted we might learn that there are many characteristics on the living by which we can pick out the typical members of the races, and further study would reveal that equally clear marks of race are registered on the skeleton. We might also learn that there are differences in measurements which can be shown statistically. Race, then, is a definite thing, but race mixture is so common and individual variations within each group are so great that it is difficult to class a considerable proportion of any population.

The fact that there are differences in men raises many interesting questions and likewise many problems. One common assumption is that people who differ from ourselves are queer, are of a lower level and therefore inferior. This is a world-wide idea. Every tribe and people which still maintains its independence looks down upon its neighbors while using laudatory terms when referring to itself. Our modern civilized writers follow the same pattern, and we are told that the Nordic is the great race, responsible for all the great men of ancient and modern history. We are told that race is everything and that if we wish to preserve this fine stock for the future we must cut off immigration, not only from Asia, but from central and southern Europe. We are told by these writers that mongrel races partake only of the baser qualities of the inferior peoples. One writer basing his conclusions on experiments with guinea-pigs tells us that a hybrid race becomes infertile after the fifth generation and that we are committing racial suicide by allowing race mixture. We are also told that mixture of two widely divergent types, such as the small Lapps and the big-framed Swedes, is apt to result in monstrosities such as huge lungs and heart in a tiny body. To all such writers race mixture is a peril—dangerous to the perpetuation of the race, dangerous to the continuance of a well-balanced physical type, dangerous because the mixed races will ultimately swallow up the superior type and reduce all to mediocrity.

There are many more problems of a more technical nature, such as the actual inheritance of certain physical characters or clusters of traits, the susceptibility of certain races to disease, the ability of men of mixed racial stocks to stand the rigors of a northern climate or the effect of tropical sunlight. But time will only permit us to examine briefly the first group of problems.

If it is true that one race has furnished all the historic leaders and has made most of the contributions towards civilization, then that fact should be widely heralded and every effort should be made to keep that stock from intermixture. If it is true that hybrid groups become infertile after the fifth generation or that monsters may result from the mixture of diverse races, then intermarriage should be prohibited by law and the appearance of half-blood children should be severely penalized.

All such claims should be subjected to the closest scrutiny, since the welfare of our race and our nation is at stake. We have within our borders millions of people not only of different racial stocks but of the three major divisions of mankind. Does this constitute a peril? Do we have any facts on which we can base conclusions or which may aid us in planning and legislating for the future? First of all let me say that we have many known offspring of diverse races and that such mixtures do not produce monstrosities. Organs such as lungs

and heart apparently are not inherited as unit characters independent of the other portions of the body. Again, we have numberless cases of race mixture, even of most diverse strains, which after many generations show undiminished fertility. Among others, let me cite such mixtures as are found in the Philippines between the Malay and Pigmy black; between the Malay and Chinese, and between the mixed offspring of this union and the Spanish and other European peoples. Equally well-known mixtures are to be found in the Indies between the Dutch and the Malay. All through Malaysia and India are thousands of Eurasians who show no tendency toward decreased fertility. In America we find the same situation among the offspring of Indian-French and the Indian-Spanish unions. Apparently then we can dismiss the claim that race mixture is equivalent to race suicide.

The claim that racial superiority is established by the accomplishments of a people is fortunately subject to direct investigation. The advocate of Nordic supremacy points to the present dominance of northern Europe and America and says, "The proof of superiority is before you. The countries dominated by the Nordics lead in civilization. Dominance is proof of superiority." Let us test this claim for a moment.

In the year 2500 B. C. Egypt led the world. It was furthest advanced in all the arts and crafts of civilization. Had you asked the Pharaoh of that period if there was a superior race of people he doubtless would have said, "Certainly, and we are it." At about that time a Mediterranean people were developing a civilization on the island of Crete, but they did not rank with the Egyptians of the time. By the year 1500 B. C. they had progressed far beyond the civilization of the Nile and by every right they could have proclaimed themselves a superior people. This was just at the time the rude barbarians from the north, the tribal kings of the Odyssey and the Iliad, were pushing into Greece. Had you sought to compare these rude herdsmen with the Cretans of the Minoan period you would have been laughed to scorn. Yet they overcame the Cretans, borrowed liberally of their culture, intermarried with them, and by the year 500 B. C. this mixed population produced the golden days of Greece. Surely they were the dominant people of that age. By the beginning of our era Rome had wrested the leadership from Greece and was attempting to subdue the rude barbarians of the north. If you wish to learn what the Romans thought of our ancestors in central and northern Europe and in the British Isles, just read again your Cicero and your Caesar. There was no doubt in the mind of the Roman but that he belonged to the great race. But the northern barbarians showed themselves capable of learning, and ere long they overthrew Roman power and are now the leaders of civilization.

Apparently then the fact that a nation or race is dominant at any particular time is no assurance that it will retain the leadership. Archeology and history teach us that civilization has shifted from one region and people to another, and that the less advanced people of one period become the leaders in another age.

The presence of many races and peoples in America does raise real problems, problems requiring the greatest statesmanship and tolerance. Race mixture will continue, we will become more of a hybrid people than we are at present; but if we scan the history of the past or consider the known facts of race and race mixture we need have no fear for America of the future.

# THE PROGRESS OF SCIENCE

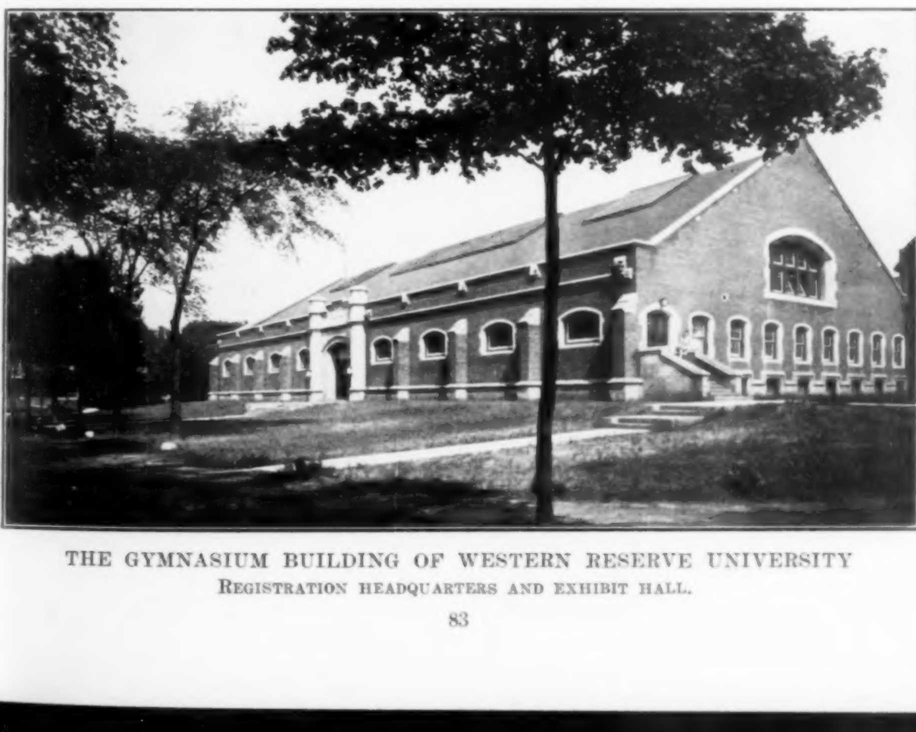
## THE CLEVELAND MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AND ASSOCIATED SCIENTIFIC SOCIETIES

THE eighty-seventh meeting of the American Association for the Advancement of Science will be held in Cleveland during the convocation week beginning December 29, 1930. This will be the fourth time the association has met in Cleveland, the other meetings having occurred in 1853, 1888 and 1912–13. Besides the fifteen sections of the association about forty independent societies will hold scientific sessions.

The societies which deal with the social and economic sciences have preferred to hold their sessions in the hotels of the down-town district, but the remaining ones, concerned chiefly with the natural and exact sciences, will have their sessions mainly in twenty buildings of Western Reserve University and Case School of Applied Science, both situated at University Circle about four miles from the down-town area.

The registration headquarters for the University Circle group will be located in the gymnasium of Western Reserve University. In the center of the large floor will be located such things as the registration desks, post-office, telegraph and telephone equipment, information desk and bureau for validation of railroad tickets, while in booths around the walls will be placed the general scientific and commercial exhibits dealing with recent advances in pure and applied science. The gymnasium thus provides a place where members and visitors may find a common meeting ground. The news service department for the convention will be located in a wing of the same building.

The opening session will be held downtown in the Music Hall of the Public Auditorium. After brief addresses of welcome the president-elect, Dr. Thomas Hunt Morgan, director of the Kerckhoff Laboratories of the Biological Sciences



THE GYMNASIUM BUILDING OF WESTERN RESERVE UNIVERSITY
REGISTRATION HEADQUARTERS AND EXHIBIT HALL.

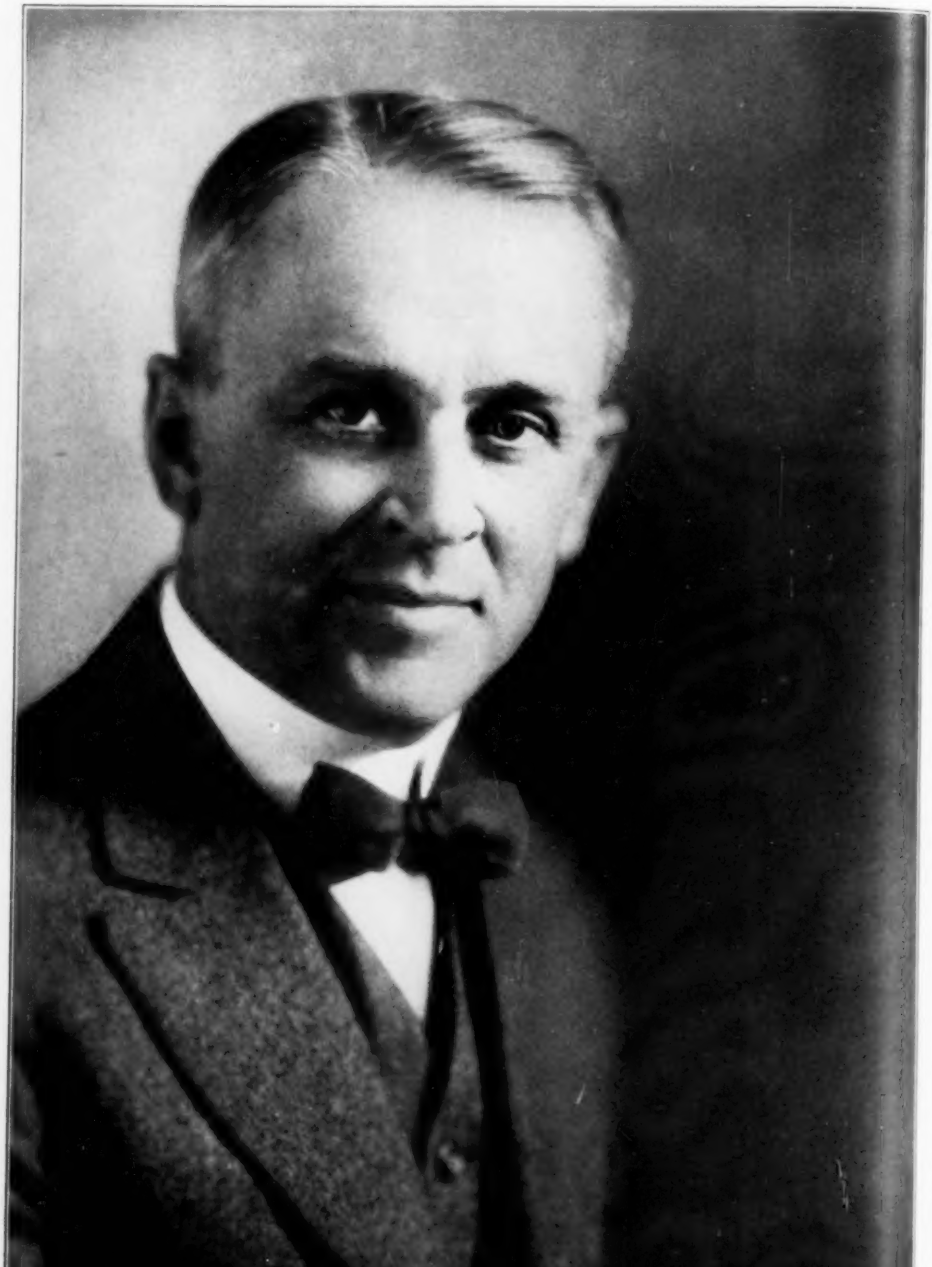
DR. THOMAS HUNT MORGAN
PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE SCHOOL OF MEDICINE OF WESTERN RESERVE UNIVERSITY

of the California Institute of Technology and president of the National Academy of Sciences, will introduce the retiring president, Dr. Robert Andrews Millikan, head of the California Institute of Technology and director of the Norman Bridge Laboratory of Physics, the subject of whose address, the main lecture of the meeting, will be "Atomic Synthesis and Atomic Disintegration." These exercises will be followed by the usual reception, which will be held in the same building.

Meeting places for about two hundred sessions of the various sections and societies have been assigned, where scientific and technical papers will be read and discussed. But, besides these papers, the program includes the usual laboratory demonstrations, symposia and general addresses, a number of which will be of interest to those who are not specialists. Among the latter may be mentioned the Sigma Xi lecture on "The Science of Photography," to be given on Tuesday evening in the John Hay High School Auditorium by Dr. C. E. K. Mees, of the Eastman Kodak Company. Many will desire to hear the annual Josiah Willard Gibbs lecture, arranged by the American Mathematical Society, which is to be given on Tuesday afternoon in the auditorium of the John Hay High School by Dr. Edwin B. Wilson, of Harvard University. Dr. Wilson's subject, "Reminiscences of Josiah Willard Gibbs," is especially appropriate when we recall that he was a student and colleague of the eminent scientist. Immediately following Dr. Wilson's address the Sigma Xi dinner will be held at the Cleveland Club, which is directly across the street from the John Hay High School. On Wednesday afternoon Professor Harlow Shapley, director of the Harvard College Observatory, will speak on "Galactic Observations." This address by a most renowned authority will be given in the Allen Memorial Medical Library. Another general session lecture will be one by Dr. Aleš Hrdlička on the subject, "Animal-like Manifestations in the Human Child."

It is to be regretted that congenial scientific spirits find so little time for social intercourse, nevertheless, the local committee has planned the usual luncheons, teas, dinners and smokers. Those



DR. ROBERT ANDREWS MILLIKAN
RETIRING PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE PHYSICAL LABORATORY OF THE CASE SCHOOL OF APPLIED SCIENCE

registering will have entrée to the Cleveland Club and to the Art Museum. There will be daily excursions to Nela Park, a unique institution of the General Electric Company. Tickets for the various play-houses and symphony concerts will be available at the registration headquarters in the gymnasium.

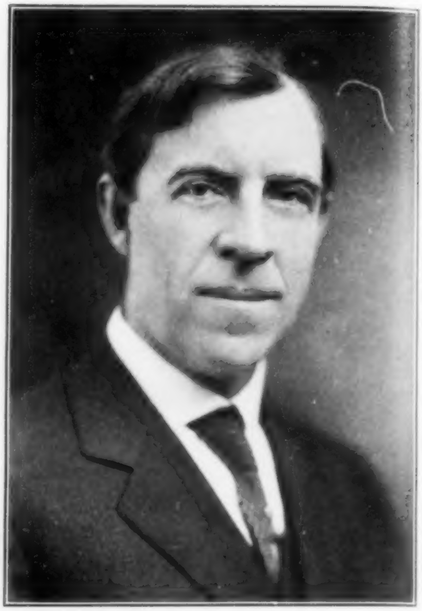
The local arrangements for the meeting at University Circle are in the hands of an executive committee, of which Dr. Harry W. Mountcastle, professor of physics and astronomy in Western Reserve University, is the active chairman. Dr. Robert E. Vinson, president of Western Reserve University, is the honorary chairman, while the Case School of Applied Science is represented by its president, Dr. William E. Wickenden, as honorary vice-chairman. The officers of the association, the Cleveland local committee, with its various special committees, and the Convention Board of the Cleveland Chamber of Commerce are all cooperating in the endeavor to make this one of the most enjoyable convocations which the association has held.

The council of the American Association will hold a session each day during convocation week. The executive committee also holds daily meetings.

The Secretaries' Conference, a special committee of the American Association, plans to hold its annual dinner and session at Cleveland. The secretary of this conference is Dr. Harley J. Van Cleave, secretary of the American Microscopical Society, who has charge of the program. The chairman is Dr. Philip Fox, secretary of Section D. The conference consists of the secretaries of the association sections, the secretaries of the associated societies and the members of the executive committee of the association.

The Academy Conference of the American Association is planning to hold its Cleveland session at the close of the first council session. This conference consists of the council representatives of the affiliated academies of sci-

DR. G. A. BLISS
PROFESSOR OF MATHEMATICS, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF MATHEMATICS.



DR. F. K. RICHTMYER
PROFESSOR OF PHYSICS, CORNELL UNIVERSITY; CHAIRMAN OF THE SECTION OF PHYSICS.

DR. JAMES F. NORRIS
PROFESSOR OF ORGANIC CHEMISTRY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; CHAIRMAN OF THE SECTION OF CHEMISTRY.

DR. D. W. MOREHOUSE
PROFESSOR OF ASTRONOMY AND PRESIDENT OF DRAKE UNIVERSITY; CHAIRMAN OF THE SECTION OF ASTRONOMY.

DR. EDSON S. BASTIN
PROFESSOR OF ECONOMIC GEOLOGY, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF GEOLOGY AND GEOGRAPHY.

DR. WM. A. RILEY
PROFESSOR OF ZOOLOGY, UNIVERSITY OF MINNESOTA; CHAIRMAN OF THE SECTION OF ZOOLOGICAL SCIENCES.

DR. E. J. KRAUS
PROFESSOR OF BOTANY, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF BOTANICAL SCIENCES.

DR. CARL E. GUTHE
DIRECTOR OF THE MUSEUM OF ANTHROPOLOGY, UNIVERSITY OF MICHIGAN; CHAIRMAN OF THE SECTION OF ANTHROPOLOGY.

ence and three representatives of the association. The secretary of the conference this year is Dr. Chancey Juday, of the Wisconsin Academy, who has charge of the program. The chairman is Dr. D. W. Morehouse, of the Iowa Academy.

The eighth annual award of the American Association prize, of one thousand dollars, will be made to the author of a paper presented at the Cleveland meeting. Through the generosity of an anonymous member seven of these prizes have thus far been awarded. The prize is awarded each year to the author of a noteworthy paper presented at the annual meeting. It is not necessary that the author be a member of the association. All papers appearing in the General Program are automatically eligible, excepting invited papers and presidential and vice-presidential addresses. In making the award no attempt will be made to select the "best" paper presented, for useful comparisons are not possible in different fields of science; the intention is simply that the prize shall be awarded to the author of some notable contribution presented at Cleveland. Previously published work may be considered when pertinent. The donor of the prize desires to aid younger authors by this means rather than to honor older men. The prize is not to be awarded in the same field of science for two consecutive years.

DR. FRANK B. JEWETT

PRESIDENT OF THE BELL TELEPHONE LABORATORIES: CHAIRMAN OF THE SECTION OF ENGINEERING.

DR. EDWIN G. BORING

PROFESSOR OF PSYCHOLOGY, HARVARD UNIVERSITY; CHAIRMAN OF THE SECTION OF PSYCHOLOGY.

A list of the names of those to whom the association prize has been awarded is shown below, together with the topics dealt with in the winning papers.

(1) The Cincinnati award, January, 1924. L. E. Dickson, for contributions to the theory of numbers.

(2) The Washington award, January, 1925. Divided equally between Dr. Edwin P. Hubble, for contributions on spiral nebulae, and Dr. L. R. Cleveland, for contributions on the physiology of termites and their intestinal protozoa.

(3) The Kansas City award, January, 1926.

Dr. Dayton C. Miller, for contributions on the ether-drift experiment.

(4) The Philadelphia award, January, 1927. Dr. George D. Birkhoff, for mathematical criticism of some physical theories.

(5) The Nashville award, January, 1928. H. J. Muller, for contributions on the influence of X-rays on genes and chromosomes.

(6) The New York award, January, 1929. Oliver Kamm, for contributions on the hormones of the pituitary gland.

(7) The Des Moines award, January, 1930. A. J. Dempster, for contributions on the reflection of protons from a calcite crystal.

All members of the association are asked to secure new members or to send to the permanent secretary's office in Washington names and addresses of persons who might be interested in joining the association. Copies of a booklet on "The Organization and Work of the American Association," as well as membership application cards and sample copies of the journals, may be secured at any time from the permanent secretary office. Membership in the association includes a subscription to the weekly journal *Science* or the SCIENTIFIC MONTHLY, for the calendar year beginning at the close of the annual meeting. The journal alone is worth more than the annual membership dues. Annual members of the association may have both *Science* and the SCIENTIFIC MONTHLY by paying $3.00 in addition to the annual dues ($8.00 in all), if the additional payment accompanies the remittance of annual dues. Annual members of the association may also subscribe for the *Science News-Letter* at the specially reduced price of $3.00 per year, if the additional remittances accompany their payment of dues in each case. Life members may receive one or both of the extra journals by paying $3.00 for each subscription.

New members of the association regularly pay an entrance fee of $5.00, but this year that fee is remitted to members

DEAN WALTER C. COFFEY

DIRECTOR OF THE DEPARTMENT OF AGRICULTURE, UNIVERSITY OF MINNESOTA; CHAIRMAN OF THE SECTION OF AGRICULTURE.

DR. LEONARD V. KOOS

PROFESSOR OF EDUCATION, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF EDUCATION.

of any associated organizations, including the affiliated state academies. Those who take advantage of this privilege and join at the Cleveland meeting without paying the entrance fee should fill in the blanks on a blue membership application card and present card and dues for 1930–31 ($5.00) when they register. All who attend the Cleveland meeting are asked to join the American Association when they register, unless they are already enrolled.

Those who are not members of the American Association and who do not wish to join at this time are invited to become associates for this meeting. The associate fee is $5.00. Associates have all the privileges of the meeting, except voting, and they will receive the general reports of the meeting when these are published about February 1. They are to register without paying any registration fee. Associate fees will be used to help defray the costs of the meeting.

DR. LEONARD P. AYRES
VICE-PRESIDENT OF THE CLEVELAND TRUST COMPANY; CHAIRMAN OF THE SECTION OF SOCIAL AND ECONOMIC SCIENCES.

DR. LOUIS B. WILSON
PROFESSOR OF PATHOLOGY AND DIRECTOR OF THE MAYO FOUNDATION; CHAIRMAN OF THE SECTION OF MEDICAL SCIENCES.

Visitors from outside of the United States and Canada who are not members of the association may be invited to the meeting as foreign associates. Members of the association may recommend to the permanent secretary persons who should receive official invitations, giving reasons. Eligibility to this honor is about the same as eligibility to fellowship in the association.

Much information concerning such things as hotel headquarters, transportation, meeting places and other details will be found in the preliminary program published in the issue of *Science* for November 28, 1930. The editor of this article is Dr. Burton E. Livingston, permanent secretary of the American Association for the Advancement of Science, who may be addressed at the Smithsonian Institution Building, Washington, D. C.

## THE AWARD OF THE NOBEL PRIZE IN MEDICINE TO DR. KARL LANDSTEINER

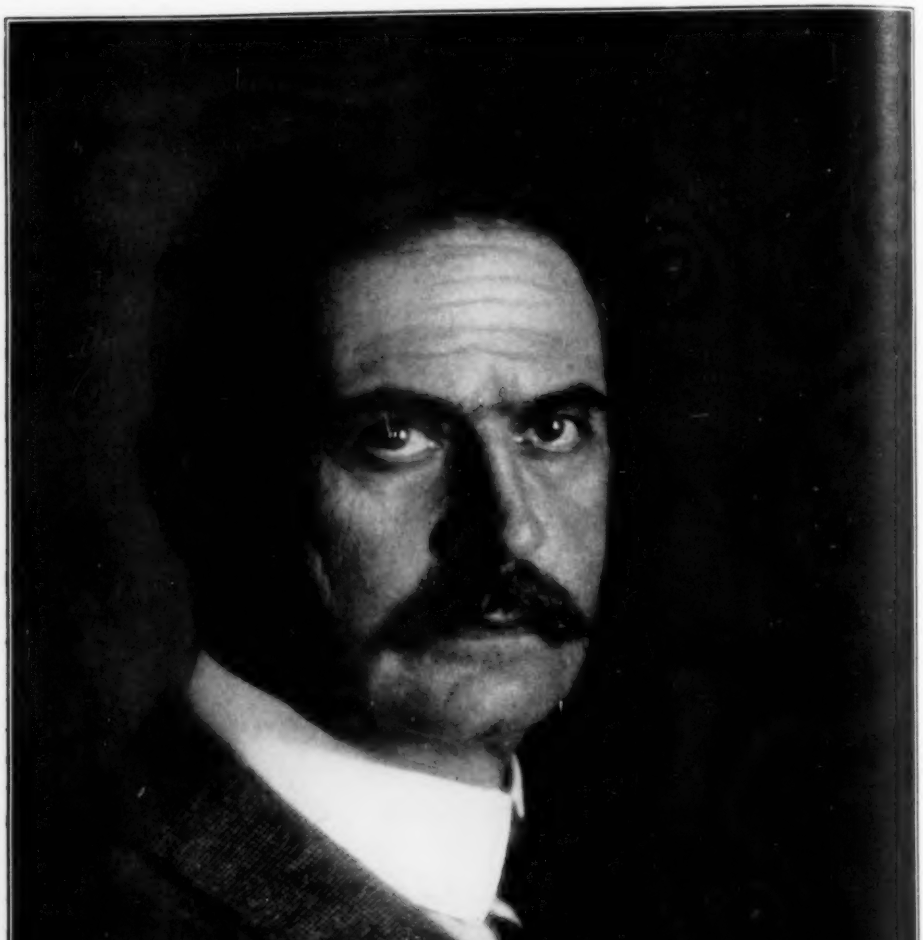
The establishment of the Nobel Prize has had a value of far greater significance than the tangible rewards accruing to the recipients. It has created international public recognition of achievements which, in the ordinary preoccupations of men with material affairs, have often been completely neglected, or postponed until long after the death of the man or woman who has enriched human understanding. In its scientific awards the commission which decides these matters has been extraordinarily well advised, and almost all its decisions have met with the enthusiastic approval of those most competent to know. In consequence, the attention of a world concentrated on the temporary problems of political and economic affairs has been periodically diverted to the contemplation of the labors of the few who—undisturbed by the competitive turmoil, and often indifferent to material success—are making permanent contributions to the progress of intelligence which is civilization. And it is a good deal to admire even if one does not wholly understand. The Nobel Prize Commission has almost invariably granted its awards for solid fundamental achievement which, without its wise judgments, would have been crowded out of public attention by more sensational things and which would, as often in the past, have penetrated to recognition only in the wake of later practical applications.

In the ranks of the others so honored in his own field of study—Behring (1901), Koch (1905), Ehrlich and Metchnikoff (1908), Richet (1913) and Bordet (1919)—Landsteiner takes his rightful place, long granted him individually by immunologists the world over, most of whom have been his admiring and grateful pupils.

The particular study for which the prize was bestowed was carried out as long ago as 1900. In his paper of 1901 the foundation for a new chapter in immunology was laid, and the tentative classification of human blood groups outlined in this publication was completed in the following year by Landsteiner's pupils, Descastello and Stürli, working under his direction. Since that time many excellent elaborations of this work have been published, but nothing was fundamentally changed or added. In its consequences upon practical medicine and surgery, the influence of these studies has been considerable, but they have had a profound reaction as well upon genetics, anthropology and zoology.

Though important and fundamental, this work is only one of a series of achievements any one of which might have been cited as the immediate reason for the awarding of the prize. Since 1894, Landsteiner has published about 115 papers, either alone or with various pupils. The amount of work that he has inspired probably far exceeds in the number of titles the communications which stand in his name. The distinguishing characteristics of Landsteiner's investigations are great originality of approach and an extraordinary mastery of the fundamental sciences. Without his broad knowledge of certain branches of chemistry and of physics, much of his most important work would have been impossible.

Into his earlier period fall a considerable number of purely chemical investigations, such as a study on the behavior of diazo-benzol upon potassium permanganate, on chloric acid, on glycolaldehyde and on color reactions of proteins with sulphurous acid and the phenols. By his earlier purely chemical interests he was induced to study the chemistry of antigen-antibody reactions, and occupied himself with chemical-pathological problems dealing with de-



DR. KARL LANDSTEINER

generation of the kidneys and the interrelationship of ferments and antiferments. During this earlier period, also, a number of studies in pathological morphology were published which may be regarded as exercises of general training and have no special significance in his development. In the first decade of the present century he published his important studies, with Finger, upon the susceptibility of monkeys to syphilis, as well as observations upon paroxysmal hemoglobinuria which established the mechanism responsible for this condition. At this time he also began inquiries into the immunological significance of the lipoids. In 1909 came his successful transmission of poliomyelitis to monkeys, this being—with the work of Flexner and Lewis at the Rockefeller Institute—the fundamental observation upon the infectious nature of a group of diseases of the central nervous system now recognized to be due to filterable agents. His extraordinary versatility is evident in the fact that together with these purely biological studies he was already beginning his investigations into the behavior of antigen and antibody in the electrical field, upon the application of adsorption phenomena in antibody union and in physical analyses of specific precipitation and alexin fixation.

Landsteiner had thus, before 1914, in a series of investigations covering an extraordinarily wide field of endeavor, made fundamental contributions to the experimental study of syphilis and of poliomyelitis, had revealed the existence of human blood groups, and had basically modified our points of view regarding antigen-antibody reactions. In addition to this, in communications of less fundamental importance he had perfected methods of immunological technique and had occupied himself with purely bacteriological experimentation such as the cultivation of the virus of fowl plague, the technique of treponema demonstration, and the nature of the hemotoxins of the anthrax group of bacteria. Though many of his investigations up to that time were of the greatest importance and include the particular work for which the Nobel Prize was granted him, his most brilliant work was yet to come. None of the investigations so far mentioned will, in our estimation, possess so permanent and fundamental an influence upon the future development of immunology as his studies upon the chemical modifications of the antigens which were begun about 1913 and have been carried on in some twenty odd publications from that time to the present day.

Obermeyer and Pick had found, in 1906, that the specificity of proteins could be altered when the aromatic radicals were modified by the introduction of iodine, $NO_2$ and $N=N$ into the protein molecule. Such altered proteins produced antibodies which were specific for the alteration form of protein used in the immunization but not specific for the species from which the protein was derived. From such observations grew a theory of specificity which for some time was generally accepted. Landsteiner, with a number of pupils, found that species specificity could be modified in many ways other than by alteration of the aromatic rings. He produced modified proteins by esterification with acid alcohol, by methylation and by a number of other methods which produced changes not affecting the aromatic radicles alone. He also modified protein by treatment with formaldehyde and by combining horse serum with derivatives obtained from various amino-compounds. By a series of investigations with the latter substances entirely too complex to be outlined here, he was able to bring strong evidence to indicate that the specificity of a protein antigen depends upon the chemical structure of a

relatively small part of the large protein molecule, and that when substitutions were made in the aromatic nuclei, the relative position, in the aromatic nucleus of the added group, of the significant radicle was as important as the substance introduced. None of this work could have been done without a broad knowledge and experience both in immunology and in the technique and reasoning of organic chemistry.

In carrying out this work, Landsteiner also found that if he produced antibodies by the immunization of an animal with a protein combined with a non-antigenic substance such as metanilic acid, the antibodies so produced, while specific for the compound protein that had incited them, would also react with the added group or substance, though the latter in itself was non-antigenic. The added group, in other words, was able to bind the specific antibody in vitro, thus rendering the antibody unable to react with the whole antigen, that is, with the protein into which the group had been introduced. This laid the foundation for our present knowledge of partial antigens, a branch of knowledge which has already become of the greatest importance in the study of bacterial antigens.

In its fundamental influence upon bacteriology, his latest work, published in 1928 and 1929 with Van der Scher, is perhaps the most significant of all. In these papers he reports upon experiments in which he prepared levo-, dextro- and meso-paraaminotartranilic acids and with these amino acids produced azo-proteins from horse serum. By immunization of rabbits with these azo-proteins he obtained immune sera which differentiated sharply the three antigens, which were identical in every other respect, but possessed stereoisomeric groups, thus indicating a specificity depending upon the asymmetric carbon atom. He suggests in this communication that since the tartaric acids by their chemical constitution belong to the same substances as sugar acids, these results may have bearing upon the specificity of bacteria containing carbohydrate partial antigens, and indeed this suggestion has already borne fruit for pneumococcus antigens in the hands of Goebel and Avery.

It has been often said that the qualities which make for great scientific achievements are very similar to those which lead to artistic production. At any rate, in most great biologists there has been an artistic streak which in Landsteiner—a typical Viennese—has taken the form of music. Indeed, though Landsteiner is fortunately now an American by adoption, his training and his personality and, we believe, the foundations of his great achievements are typically those of Vienna in her best days. We may claim him with pleasure as one of us now, but we can not justly claim any credit for his development, largely because almost all his great work was begun—and much of it finished long before he came to America. Like Loeb, Edmund B. Wilson and numerous other great men, his most characteristic personal trait is an almost childlike simplicity and gentleness. Perhaps one of the most descriptive facts that one can state in characterizing him is that the public knew practically nothing of him and few, outside of his close personal circle and those who had followed his work, knew that he was one of the few great living scientists until he was adjudged so by a jury of his professional colleagues through the Nobel Prize Commission.

HANS ZINSSER